PROCEEDINGS
OF THE
FIFTH PACIFIC BASIN
CENTRAL BANK ECONOMISTS' CONFERENCE:

SUPPLY-SIDE SHOCKS,
THE BALANCE OF PAYMENTS
AND MONETARY POLICY

BANK OF CANADA
KEVIN CLINTON, Editor
Published SEPTEMBER 1982

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PREFACE

It was my privilege to act on behalf of the Bank of Canada as Chairman of the Fifth Pacific Basin Central Bank Economists' Conference held in Vancouver in the fall of 1981. There were participants from ten countries and two international institutions. For the first time the Bank of Mexico was represented at the Conference.

The theme of the Conference is used as the subtitle to these Proceedings: "Supply-Side Shocks, the Balance of Payments and Monetary Policy." This theme was deliberately chosen in order to switch the emphasis from the topic of econometric model-building per se that had preoccupied previous Conferences, towards the implementation of models to analyze some important aspects of economic adjustment. Central bank economists naturally tend to emphasize the financial aspects of the adjustments to real shocks to the system, so a number of the papers give prominence to exchange rates and to various monetary policy options. In individual country models, the effects on the level and composition of output and employment were also considered.

Most of the papers analyze the implications of an increase in exogenous world prices. For the most part, each paper was presented in the form of a discussion paper rather than as a fully finished piece, and should be regarded as such. In some cases where the models were new or substantially modified to aid in handling supply-side questions, the findings are preliminary; indeed, the authors' views were in the process of evolution at the time of writing.

Criticism and advice are vital to economists, and one of the most useful aspects of these Conferences is the feedback authors receive from colleagues working on the same subjects but with differing international perspectives. The opportunity to present work to an informed audience is especially valuable to economists from institutions that have neither extensive in-house resources nor frequent communication with outside economists. At the Bank of Canada we are more fortunate than most in these respects, yet we learn much from our colleagues in the Pacific Basin group.

It is with pleasure that I record my appreciation of the active participation of the member institutions and their economists. Thanks are also due John Helliwell for his enthusiastic and thorough contribution as Moderator and Lea-Anne Solomonian for editorial assistance.

Special thanks should go to George Freeman, former Deputy Governor of the Bank of Canada. He was kind enough, near the eve of his retirement, to wrest himself away from the problems of animal husbandry near Arnprior to address the Conference on his experience in the practice of monetary policy. George, with typical forthrightness and self-deprecatory humour, reminded the delegates that there are political as well as economic constraints on central bank policy which economists must heed if their advice is to be relevant.

Kevin Clinton, Editor

PRÉFACE

A l'automne 1981, j'ai eu le privilège de présider, en qualité de représentant de la Banque du Canada, les travaux de la 5^{e} Conférence des économistes de banques centrales du Pacifique. Cette conférence, qui s'est tenue à Vancouver, réunissait les représentants de dix pays et de deux organisations internationales. C'était la première fois que la Banque du Mexique participait à ces assises.

Le thème de la Conférence, "Chocs de l'offre, balance des paiements et politique monétaire", est utilisé comme sous-titre du présent compte rendu. Ce thème avait été choisi dans un souci délibéré des organisateurs de s'éloigner du sujet de la construction des modèles économétriques, qui avait été au centre des débats des conférences précédentes, pour se tourner vers l'application de ces modèles à l'analyse de certains aspects importants des ajustements de l'économie. Les économistes des banques centrales ont naturellement tendance à insister sur les aspects financiers des ajustements que le système effectue en réaction à des chocs réels. C'est ainsi qu'un grand nombre des études présentées accordent une place de choix aux taux de change et aux divers choix possibles en matière de politique monétaire. Les effets de ces chocs sur l'emploi et le niveau et la composition de la production ne sont pas négligés dans les modèles nationaux.

La plupart des travaux analysent les répercussions d'une augmentation de la variable exogène que sont les prix mondiaux. Presque tous les travaux ont été présentés, non comme des études définitives, mais comme de simples documents de discussion, et ils doivent être considérés comme tels. Lorsque les modèles étaient nouveaux ou avaient été considérablement modifiés pour permettre de mieux comprendre des questions relatives à l'offre, les textes soumis ne contenaient que des ébauches de conclusion. Cela s'explique par le fait que les idées des auteurs n'étaient pas bien arrêtées au moment de leur formulation.

Pour l'économiste, les conseils et les avis critiques jouent un rôle essential, et les conférences de ce genre lui sont d'autant plus utiles qu'elles lui permettent de recevoir les commentaires de collègues étrangers qui s'intéressent aux mêmes sujets, mais les abordent dans des perspectives différentes. Le fait de pouvoir exposer les résultats de recherches à des réunions de spécialistes comme celle-là a une valeur inestimable surtout pour les économistes qui appartiennent à des institutions qui ont un personnel limité ou peu de contacts avec leurs collègues étrangers. Bien que, à cet égard, les choses soient plus faciles pour nous, à la Banque du Canada, nous avons appris beaucoup des autres représentants des pays du Pacifique.

Je tiens à dire combien j'ai apprécié la contribution des autres institutions-membres et de leurs économistes. Je tiens également à remercier John Helliwell pour l'enthousiasme et le brio avec lesquels il s'est acquitté de ses fonctions d'animateur et Lea-Anne Solomonian pour les services qu'elles nous a rendus en tant que rédactrice.

Enfin, je crois répondre au voeu unanime de mes collègues en remerciant tout spécialement George Freeman, ancien sous-gouverneur de la Banque du Canada. A la veille de son départ à la retraite, il a accepté de bonne grâce d'aller à Vancouver partager avec nous les fruits de l'expérience qu'il a acquise dans la mise en oeuvre de la politique monétaire, laissant momentanément de côté les problèmes d'élevage qui requièrent son attention à sa ferme des environs de Arnprior. Avec la franchise qu'on lui connaît et le don unique qu'il a de se moquer de ses propres défauts, George a rappelé aux délégués que la politique d'une banque centrale est soumise à des contraintes tant politiques qu'économiques, et que les économistes doivent en tenir compte s'ils veulent prodiguer des conseils qui collent à la réalité.

Kevin Clinton, Rédacteur

1 KEYNOTE ADDRESS

KEYNOTE ADDRESS:

HOW SHOULD MONETARY POLICY AND EXCHANGE RATE MANAGEMENT RESPOND TO SUPPLY AND PRICE CHANGES IN INTERNATIONAL MARKETS?

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The late 1970s and early 1980s have offered to model-builders and policymakers a wide range of external shocks. Also over this period traditional views changed as to how stabilization policy tools can and ought to be used. Supply shocks and supply modelling provide the themes of this Conference with the goal being to assess the evidence about how monetary and exchange rate policies affect the ability of national and world economies to digest supply shocks.

In the various papers for this Conference and in much of the current literature, the most usual form for such shocks is an increase in the price of an imported raw material, usually taken to be crude oil. Such a change in relative prices, when seen from an international perspective, is in itself neither a supply shock nor a demand shock but just a change in relative prices whose cause and consequences need to be investigated. From the international perspective, supply shocks of a more traditional sort would come from abnormal weather or crop conditions, or unexpected changes in technology or resource stocks. Any of these would cause changes in the size as well as the distribution of world output. The post-1973 changes in world oil prices were broadly not of this type, but were due to changes in the chosen extraction rate for established OPEC oil reserves. This gave rise more to a redistribution of potential world output over time and among countries, than to a reduction in global supply potential.

Having made this distinction between supply shocks and relative price changes, I do not intend to work it very hard since it is probably the case that the finiteness of low-cost world oil stocks and the costs of alternatives were generally underestimated in the pre-1973 world, so that the post-1973 events took on many of the characteristics of a genuine supply shock, with the present value of the perceived income loss in the oil-using countries being greater than the offsetting gain among the producers, even putting aside the macroeconomic costs which I shall be describing later. And of course, it could be argued that the events in Iran that led to the second jump in oil prices did represent real losses of world supply potential, not just in lives and equipment, but also in the reduced probability that some of the world's richest resource deposits would be available on a secure and predictable basis. The heightened insecurity of supply has a further downward impact on the expected value of that supply, since the downstream flexibility energy-using nations are led to adopt will in general be costly to provide.

The events of the 1970s have forced model-builders and policymakers alike to question the inevitability of what previously seemed inexorable growth of world trade and productivity. The supply potential that model-builders had often treated as an exogenous trend (or even without limit), and planners an attainable target, has been brought into the centre of the stage. As actual growth rates of output have fallen while inflation rates have risen, policymakers cannot make sensible judgements about policy without having a reasonable idea of the size and nature of the reductions in potential output.

Model-builders have responded by paying more attention to the specification of potential output. This has involved making explicit allowance for inputs of energy and sometimes other raw materials, and in some instances making the vintage structure more explicit, thus reducing the speed or increasing the costs of adapting factor inputs to the extent indicated by current factor prices. For countries that are both producers and consumers, the nature of the required model changes is more extensive as models also have to deal with the factor requirements, income distribution, and foreign trade consequences of the booming resource sector, and hence show the interplay of the two sectors in determining national output, income, prices, wages, and the exchange rate. I will return to some specific model-building issues in a few minutes.

Policymakers have not had the luxury of being able to wait until new models were ready to explain the supply-shocked world. In the aftermath of OPEC I (the name sometimes used for the 1973-74 increases in world oil prices), policymakers had to decide how to respond to stagflation, an uncomfortable combination of increasing inflation and falling output. There were theoretical reasons and even model simulations to support the view that the worsening terms of trade in the oil-consuming countries would cause real income reductions that would lead to drops in domestic demand that were most unlikely to be offset, at least in the short run, by higher OPEC spending. Thus the typical oil-consuming country found itself with higher prices, higher unemployment, and a looming trade deficit. Policymakers in these uncomfortable circumstances had to choose both targets and instruments. International organizations were counselling on the one hand that inflation needed to be checked and on the other that it was infeasible for the oil-consuming countries collectively to balance their trade account with OPEC, and that competitive devaluations and other similar attempts to obtain a trade balance would be largely at the expense of other oil importers, often those with least easy access to credit facilities.

Subsequent analytic work (e.g., Sachs (1981)) has confirmed that one thing this policy should not do in the face of such a shock is to choose a zero trade balance as a policy goal. His argument, which deals with a small open economy and thus does not deal with the collective implausibility of a target that would require OPEC to spend all its oil income, is based on the role of the trade balance, with its matching capital flows, as a key element in the optimal readjustment of private investment and savings decisions in response to the supply shock. In a model of far-sighted intertemporal optimization by households and firms (and presumably by governments in their own spending decisions), there is no normative significance to the trade balance, and hence no reason to impose any particular target for the trade balance in response to a supply shock. The impact of the shock on the optimal trade balance depends on whether the shocks are temporary or permanent and on their relative impacts on income and potential output.

So far, the argument rejects trade balance as a target for policy in response to a supply disturbance. By now, you will be asking yourselves what role there can be for any policy targets and policy responses in a world of far-sighted private sector optimizers. As well, you might imagine, to find any role for policy it is necessary to assume that in some way the government and its advisers have better foresight or a longer planning horizon than private planners. Sachs (1981) gets this result by assuming that households have finite lives and leave no bequests, while governments plan for the infinite future. "New classical macroeconomists" would probably argue that, to the contrary, households have a longer planning horizon and a stronger bequest motive than governments. They would contend that oligarchies look after their own interests, while democracies are run with a three- to five-year horizon and some inclination to leave an awkward bequest for the new government to deal with.

Whatever one's view on these issues, it seems clear that the role for policy in these clairvoyant optimizing models depends on rather special assumptions about the behaviour of the public and private sectors. Policymakers and private decision-makers in the real post-OPEC world are operating in an environment that they regard as highly uncertain, an environment in which clairvoyance on anyone's part seems an unlikely place to start the analysis. What happens to the role for policy when uncertainty is introduced? If one is willing to assume that markets are fully competitive and flexible, the issue now comes to turn on the relative informational positions of the public and private sectors. If governments are in a better position to judge which shocks are temporary and to separate the cyclical from the long-run adjustments to supply disturbances, then there is a role for them to operate so as to smooth the adjustment process either by altering the policy variables under their control or by revealing to private decision-makers the information and analysis that would permit private decision-makers themselves to obtain smoother adjustments. Whether it is better for the government to provide the information or to adjust the instruments depends on a complex set of conditions including on the one hand, the willingness and ability of private sector units to perform intertemporal arbitrage on the necessary scale in markets for goods, securities, and foreign exchange, and, on the other hand, on the uncertainties and expectations raised in the private sector by unexpected changes in policy variables.

Thus, it seems to me that it is extraordinarily difficult to judge what scope there is for policy actions to offset supply shocks. Several kinds of research seem necessary, some of which could profitably be undertaken within central banks and other government agencies. I shall focus on the monetary and exchange rate issues of special concern to central banks.

One important strand of research is to assess how well private markets have foreseen the consequences of supply shocks, and whether speculative arbitrage has done as much as could have been expected, given the information at hand, to cushion movements in interest rates and exchange rates. The simplest question for research is whether forward exchange rates or forward security prices are optimal predictors of future spot prices. As predictors, the forward prices can be compared against expert opinion as has been done recently at the Federal Reserve Bank of San Francisco (Throop (1981)), or against behavioural economic models based only on information available at the time the forecasts were made, as in recent work on the foreign exchange market by Paul Boothe (1981), now at the Bank of Canada. There is much to be done in this vein and it is too early to be sure about the results. However, the two studies I referred to both found consistently unexploited possibilities for intertemporal arbitrage. The implication of these results, if they should prove to be of more general applicability, is that interest rates and exchange rates are more volatile (or, more precisely, are less efficient signalling devices) than they should be, even given the inevitable uncertainty about the evolution of private markets and public policies.

To move from these results, if they should be indicative, to a helpful rule or strategy for policy intervention, it is first necessary to establish a better understanding of the medium- and long-term consequences of supply shocks, and also to identify the key prices and quantities that are important for private sector decisions, and thus might be suitable candidates for stabilization. This suggests two separate but important strands of research, one on the structure of financial markets and the other more focused on the underlying structure of the real economy.

The first line of research has to do with the setting of targets and operating rules for monetary and exchange rate policy. Many central banks have altered their targets and, to a lesser extent, their operating procedures, to focus on monetary aggregates rather than on interest rates. There were a number of reasons for this change in emphasis. One was a declining confidence in the information value of nominal interest rates in a world of rising and variable inflation rates. Another was increasing discouragement among policymakers about the efficacy of fine-tuning, and an increasing acceptance of classical long-run neutrality propositions that the real rate of interest is unaffected by monetary policy and that price level changes are proportional to money supply changes. These changes, when combined with the general move to more flexible exchange rates that preceded OPEC I, made it natural for monetary authorities to define targets in terms of monetary quantities, with a corresponding reduction of attention to changes in nominal interest rates and exchange rates.

What are the implications of this change in emphasis? First, of course, one can note that if the basic policy-setting is defined in terms of a monetary quantity, the automatic or "passive" monetary response to a stagflationary increase in import prices will be more restrictive than if the policy norm is defined in terms of nominal interest rates. If there is uncertainty about how much monetary policy accommodation there should be to an import price shock, then the effects of the initial policy stance may be more important than otherwise.

A second consequence of the change in emphasis is that there is likely to be, in the absence of equivalent stabilizing by private sector participants, more variability of interest rates and exchange rates than there would be if open market operations and/or exchange market intervention were aimed at reducing fluctuations in interest rates and exchange rates. In practice, of course, the operating rules have been concerned with interest rate and exchange rate variability, and the monetary growth targets have had more effect quarter-to-quarter than day-to-day, although any moves towards base control might reduce the apparent freedom to reduce interest rate variability while adhering to a target range for monetary growth.

To the extent that support for monetary growth targets has been based on belief in the neutrality of money and the constancy of real interest rates, it is currently under considerable stress, especially in North America where real rates of interest, however measured, are several times as high as in the early 1970s, and probably also higher than at any other time in history. The view that "money matters, but mostly for prices" is not likely to survive the current experiments in North America, where the effects of tight money are being felt primarily on real activity. There is, as you might guess, a classical rational expectations response to this that accepts a substantial period of real recession as a necessary learning period during which private sector participants are acquiring faith in the monetary authority's commitment to inflation-fighting. In the meantime, the argument goes, bond prices will continue to be low because there is doubt whether the iron ladies and gentlemen will be broken by political forces before the financial markets have acquired the necessary faith that inflation rates are likely to fall and stay down.

The current experience is certainly proof, if such be necessary, that monetary policy can change real interest rates by large enough amounts and for long enough to have important real effects. But what are the conclusions to be drawn about the appropriate stance for monetary policy in the face of supply shocks? One aspect of any answer depends on whether, for a particular country, the demand-reducing effects of the shock are more or less than the supply-reducing effects, and hence whether there is excess supply or demand to be a possible spur for policy response. The answer to this depends on the circumstances and the circumstances need to be unravelled by better models of real supply potential, a topic I shall deal with later on.

The second aspect of the answer depends on whether setting monetary quantities or interest rates provides a more secure framework within which private sector participants can form their expectations about the supply price of capital, the returns on savings and investment, and the future rates of growth of prices and wages. It is common to argue, in defence of setting monetary quantities rather than interest rates, that for open economies interest rates are set in world markets and that attempts to set them higher or lower will lead to domestic inflation or deflation at a rate sufficient to restore real-interest-rate parity. The evidence, however, suggests that deviations from real-interest parity, as well as from purchasing-power parity, are to be expected over the policy horizon, and hence that there is an instrument choice to be made, however constrained that choice may be.

I ought to mention, in passing, that the tight capital market linkages that might be thought to limit the power of monetary policy become the source of its potency under flexible exchange rates, in the framework made well known by Mundell (1963) and subsequently developed further by others.

I cannot leave the subject of monetary targets and instruments, especially before a group of central bank economists, without laying before you my more fundamental worry that monetary targets may have come to be accepted as policy indicators just as money itself is becoming technologically obsolete. The issue is not a new one, and the obsolescence of money will not occur overnight, but I expect that historically high interest rates will foreshorten the process and alter the stock demand for money balances in a major, and probably irreversible, way. High interest rates force banks and their customers to rethink seriously what they do for each other. What they are discovering, of course, is that banks, like other financial institutions, provide a range of financial services that can easily be priced and sold separately and not necessarily as a package paid for by forgone interest receipts on a demand balance that has little other reason for existence. It is now increasingly common for financial and non-financial businesses to make use of their computerized accounting systems to accept credits and debits on a daily basis and either pay or charge interest on net balances. The resulting barter-plus-credit system may or may not leave the commercial banks with a key role in the clearing system, which they may or may not be paid for on a piece-rate basis, and they may well continue to play key roles in the credit system if only because of their formidable size and experience. However, it would be a brave central banker who placed much faith in a low elasticity of substitution between the liabilities of different classes of financial and non-financial institutions, and hence on the stability of any definition of velocity.

This is, of course, a very damaging line of thought if it should turn out to be as relevant as I think it to be. For if there is no reliable asset demand for any class of monetary liabilities, then restricting the quantity of money does not necessarily determine the price level. Money supply control would then be a necessary but not sufficient condition for reducing the rate of inflation. This kind of worry, or the institutional changes that inspire it, may lie behind the various proposals to return to the gold standard, to adopt price and wage controls, or in some other way to anchor the price level to the supply and demand conditions for some commodity. The problem with gold is partly the gold-rush supply variability that fuelled the great price surges of earlier centuries, but also the relative unimportance of its non-monetary (i.e., non-hoarding) uses, giving rise to the possibility of big speculative surges. Wage controls, which provide a labour theory of value, suffer from the opposite problem in that hoarding and open-market operations are not feasible, raising credibility problems for the whole system. Since there is no readily available alternative to the fiat money system, it might be best to accommodate (and perhaps limit) the obsolescence of money by returning to monetary policy strategies more clearly focused on interest rates, making appropriate allowance for expected rates of inflation. In leaving this issue, I must emphasize that I have been only sharing my musings with you and not presenting anything based on current research results. It should be clear, however, that much of the current central bank econometric research on the nature and stability of money demand functions is very much to the point, and should be monitored closely on the off chance that there is something in what I have been saying.

I turn now to consider what further research should be directed towards a better understanding of the real effects of supply shocks, and hence to provide a better guide to whatever role there may be for monetary and exchange rate policies. This is a lively research area judging from the papers prepared for this and other recent conferences. I shall save until later my attempts to synthesize the very interesting papers prepared for this Conference, but it might be helpful if I spelled out at the beginning what I would take to be a minimal model that could deal with a change in the price or supply conditions of a commodity for which the home country is, in the most general case, both a producer and a consumer.

The first issue to be raised is the degree and nature of aggregation. I shall start from the assumption that most central bank model-builders and policy analysts prefer the most aggregated structure that captures the essentials of their economy and meets the main criteria for successful aggregation. Aggregation can be fearlessly performed only for commodities that are perfect substitutes, or for which the relative prices have not changed materially. The latter condition is the one most relied upon by model-builders, and energy provides the key commodity that may have roughly satisfied the criterion before 1973 but has clearly failed to do so since.

Other raw materials may also need separation for this reason, chiefly in countries for which certain commodities have an important role in production or consumption and have had important changes in relative price or supply conditions. Many of the Pacific Basin economies are based on particular commodities sold at varying terms of trade on world markets, and those industries may have the best case for special treatment. There is no requirement that only one industry should be given separate treatment. If the output of each of these industries is sold primarily on world markets and is not a key input to other production sectors, then additional disaggregation of this type does not impose great problems.

For several Pacific Basin countries, including Indonesia, Mexico, Canada, the United States, Australia, and perhaps New Zealand, there is a good case for treating energy separately as a production sector and as an input to production elsewhere. Separate treatment on the production side may be indicated not only if the sector is of substantial size, but also if prices have risen so far relative to cost that there are very large economic rents to the resource base, rents large enough to distort aggregate modelling if they were attributed to some other factor, as they generally would be in the absence of separate accounting. Indeed, the existence of large and variable economic rents to the resource base provides a good criterion for deciding which production sectors, if any, should be treated separately.

In the Canadian context, the decision to treat energy as a separate production sector was easily made on the grounds of relative output price variance as well as the size and variability of net economic rents. For example, in 1981, net economic rents from crude oil and natural gas were about $22 billion or over 7 per cent of GNP, compared to 3 per cent of GNP in 1976 and less than 1 per cent before 1973. Rents in 1981 from hydroelectricity were about 1 per cent of GNP, and those from coal much less. If we exclude the 45 per cent of oil and gas rents and all of the hydro rents that were passed on to consumers through low domestic energy prices, the oil and natural gas rents actually paid were 4 per cent of GNP in 1981.

Another common criterion for disaggregation, especially in theoretical models of open economies, is the degree to which the output of the industry is tradeable. A split between "tradeable" and "non-tradeable" sectors, sometimes referred to as an "Australian" approach after the early work of Salter (1959) and others, is more often called the "Scandinavian" approach, especially since it has become the basis for a theory of wage and price determination (summarized by Lindbeck (1979)) wherein the wage rate paid by both sectors is determined by the world-determined output price of the tradeable sector. In the Scandinavian countries, the National Accounts are organized in such a way as to facilitate disaggregation of this sort. Some recent theoretical papers (e.g., Neary and Purvis (1981) and Bruno (1981)) have used the split between tradeables and non-tradeables as a basis for analyzing the effects of raw material price shocks. If nothing definite can be said about the relative factor intensities of the two sectors, then this disaggregation does not provide more information than is obtainable from a model with a single semi-tradeable output.

If one has to choose, in empirical application, between this sort of disaggregation and one based on the relative variance of factor and output prices, I would opt for the latter. Aside from data problems, I have trouble, in an open economy, thinking of any sector whose output is not directly or indirectly tradeable. For a country like Canada, which is only slightly more diversified than the average Pacific Basin country, the mix of both imports and exports includes everything from raw materials to finished products and services, and there is for almost every product the option of doing any given stage of value-added either domestically or abroad. If housing is expensive at a particular location, then either workers are shipped about or the labour-intensive part of the production process is shifted to a location where living costs and the supply price of labour are lower. If every service, however immobile it may be, has to compete indirectly in world markets, then everything becomes more or less tradeable and the grounds for a sharp distinction are lost.

Nonetheless, even if one chooses the optimal disaggregation on other grounds, a model-builder should exploit whatever differences there may be in the tradeability of output. For example, if the energy industry is singled out for special treatment as an output sector, then it is natural to treat crude oil as having an elastic world demand at the world market price (although even this may be assuming too much with today's spectrum of prices for oil of comparable quality) while coal, natural gas, and electricity, with their higher transport costs have usually been traded on terms that permit neither side to be a complete price-taker.

Once a decision has been made about the disaggregation on the production side, it is important to set up the model to establish the appropriate links between the sectors. Some theoretical models (e.g., Neary and Purvis (1981)) treat the resource or primary sector as using only imported inputs or no inputs at all. In these conditions, the model explains the "Dutch disease" or the "de-industrialization" problem that has been the focus of much study in some energy-rich industrial countries (e.g., Barker and Brailovsky, eds. (1981)), by means of trade effects, with the exports from the energy or primary sector driving up the exchange rate and squeezing the profitability of the manufacturing sector.

For most countries, including those in the Pacific Basin, I think that one ought to consider also the competition for factors. This can arise in the labour market or in the goods market, or both. In constructing the MACE two-sector model of the Canadian economy (Helliwell and McRae (1981) and Helliwell, Boothe and McRae (1981)), we chose to ignore the relatively small operating labour requirements of the energy sector, but to include energy investment and non-energy investment as both making demands on domestic output and imported goods. Where there are major initial capital investments required per unit of energy output, as is increasingly the case in all energy-producing countries, the capital requirement for energy production provides an essential link between the energy and non-energy sectors and alters materially the dynamics of adjustment in response to a supply shock, whether of internal or external origin.

For countries whose primary sectors are very labour-intensive, the labour market linkage might be more important, although one might also need to consider the possible existence of dual labour markets that would blunt the nature of the labour competition between the two sectors. Whatever the specific features of the sectors modelled, it is necessary to exploit them so as to capture the key linkages between the sectors. Otherwise, there is little to be gained from separate treatment beyond the increase in accuracy that one might achieve by stripping the resource sector data, with their variable prices and rents, out of the data used to model the rest of the economy. I will now consider the choice of production structure for the rest of the economy.

As an important input to production, for which the relative price has changed dramatically, energy probably stands out in all countries, if only because of the dominance of crude oil in world energy use, and even more in world energy trade. For example, the implicit prices of Canadian energy imports and exports rose ten-fold between 1971 and

1980, compared to increases of less than 150 per cent in the prices of non-energy imports and exports.

Thus it seems likely that for most countries for which models are to be built with data samples including the 1960s and 1970s, and with the objective of explaining the 1980s, it will be worth considering energy as a separate input to the production process.

Initially, two main approaches were adopted for analyzing the role of energy in production. At the national level, it was common to explain energy use by real GNP and the ratio of the energy price to the price of GNP. GNP was then treated as a function of capital and labour. This was formally equivalent to having GNP and energy as weakly separable inputs into a production function for Q, defined as gross output including energy. If we assume for the moment that all energy is imported, and hence is not part of GNP, the implied function for Q is

$$Q = q(v(K,L),E) \tag{1}$$

where v(K,L) is the value-added function for GNP. Typically, elasticities of substitution were estimated in the range between 0.2 and 1.0, with more weight in the middle of the range.

Another strand of research was based on energy use in the manufacturing industry, with gross output a function (usually translog) of capital, labour, energy, and materials:

$$Q = q(K,L,E,M) \tag{2}$$

Subsequent work by Berndt and Wood (1979) tested whether it was possible to group the factors in separable bundles, and found the most acceptable grouping treated capital and energy together as a subfunction nested within the "master function" for Q:

$$Q = q((k,K,E),L,M) \tag{3}$$

This framework was then used to reconcile the notion that capital and energy were substitutes within the subfunction for K and E ("energized capital"?), while capital and energy could be complements in the over-all master function for Q. In the special case where the subfunction is CES and the master function is Cobb-Douglas, capital and energy will be substitutes in the over-all framework if the share of capital plus energy in gross output is greater than 1 - sigma, where sigma is the elasticity of substitution between energy and capital in the subfunction.

In the light of the existing empirical evidence, how should one decide what production structure to choose for the modelling of potential output? First, the results to date, from aggregate and industry studies alike, suggest that the elasticity of substitution between energy and GNP, or between energy and capital, is less than 1.0, and also less than that between capital and labour or between energy and labour. Thus, one should either adopt the capital-plus-energy bundling of equation (3), or some more flexible form that admits the same possibilities. The alternative packaging implied by equation (1) has not been heavily rejected by comparative tests, however, so it should probably be considered as well, especially as it provides the simplest starting point.

What is to be said about the choice between more and less flexible forms? The usual argument for more flexible forms is that they provide a higher order approximation to whatever the "true" function may be. On the other hand, the choice also depends on what one is willing to assume about lags, about the continually binding nature of the production function, and about the use to which the functional form is to be put. If one is willing to assume that output, except for random errors, is always on the production function based on measured factor inputs, and if there is no need to have an explicit functional form for the production function, then it is natural to choose a very flexible form that imposes little in the way of constraints, and then test to see what constraints may be safely imposed. The assumption about equilibrium is necessary because it is required in order to derive the share equations that are estimated.

If one is willing to impose the production function strictly, and wishes to use the production function directly to determine the level of output, then it is more natural to choose a more restricted form and estimate the parameters directly (as in the Bank of Canada's new SAM model to be presented here by David Rose).

A third possibility, which was employed in RDX2 and also in the MACE model developed here at U.B.C., is to assume that there is cyclical variability in the productivity of measured factor inputs, and hence to avoid either direct estimation of the production function or the estimation of parameters from factor share equations. Under this alternative view of the world, the natural way of proceeding is to derive some parameter estimates from sample averages (since the production function is assumed to hold exactly at average utilization rates), and to identify the rest from estimation of the derived factor demand equations. If one follows this strategy, one is inclined to prefer the simplest functional form that captures the main substitution possibilities in order to restrict the number of parameters to be estimated, to permit the identification of the remaining parameters from explicitly derived factor demand equations, and to permit the use of the explicit production function for given factor inputs, as a measure of potential output. The ratio of the actual level of output to potential output (which assumes average utilization rates for employed factors) is thus a measure of the rate of utilization of employed factors, and is thus a natural and important channel of linkage between the production sector and the equations determining prices, wages, imports and so on.

Another advantage of a relatively restricted functional form is that it is possible to enrich it with an explicit vintage structure. This possibility is put to considerable use in the MACE model which uses an explicit vintage bundling of capital and energy, and then uses the equation for the derived demand for energy as a means of identifying not only the long-term elasticity of substitution between capital and energy, but also the rate at which the initially chosen energy-capital ratio becomes malleable again. In a full putty/clay model, this ratio would remain fixed as long as the capital remained in use, but in a more general putty/semi-putty framework, one would anticipate, especially at the aggregate level, considerable scope for retrofitting or otherwise adjusting the amount of energy required to use the existing capital stock.

Although I have suggested that the modeller's choices of function form and estimation technique flow naturally from the way in which the production process is conceived and the uses to which the model is to be put, there remains a high payoff to setting up the modelling strategy so that the consequences of the modeller's choices can be assessed. If the results of supply shocks on potential output, and hence on the indicated stance for policy, turn out to be sensitive to the particular assumptions about production structure, then it would be advisable to test the empirical support for the chosen form against its alternatives, and to qualify the nature of the policy conclusions accordingly. There are clearly some very important linkages between the kind of production model adopted and the conclusions that one might make about past and future rates of productivity growth (whether simple measures of output per employee, or multi-factor measures), and hence about the targets and settings for monetary and exchange rate policies.

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2 MULTILATERAL MODELS AND EXCHANGE RATES

MACROECONOMIC AND EXCHANGE RATE EFFECTS OF AN OIL PRICE SHOCK UNDER ALTERNATIVE OPEC INVESTMENT SCENARIOS

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The views expressed here are those of the authors and do not necessarily reflect the views of the Board of Governors or anyone else on its staff. The authors are grateful to Joerg Dittmer for his assistance in running the simulations presented here.

1 INTRODUCTION AND SUMMARY

This paper investigates the impacts of a shock to the world price of oil on the exchange rates, external positions and domestic growth and inflation of five major industrial countries. The analysis focuses on how the impacts vary under alternative assumptions about OPEC's asset preferences in the investment of its surplus, and about the rate at which OPEC absorbs that surplus following the price increase. At one level, conventional wisdom suggests that an oil price hike will cause a country's currency to depreciate if it raises its import bill and reduces its current account balance. At another level, the ultimate impact on the exchange rate depends upon how OPEC spends and invests the proceeds of its higher export revenues. Even if a country were heavily dependent upon imported oil, a strong OPEC preference for assets denominated in that country's currency could cause the currency to appreciate. The magnitude and dynamic patterns of the impacts of an oil price shock can also vary significantly with the rate at which OPEC absorbs its surplus into higher imports.

Some of these questions have been addressed elsewhere in small theoretical models. The analytical approach employed here is similar in spirit to the portfolio balance frameworks developed by Golub (1980) and Caprio and Clark (1981) for assessing the impacts of oil price shocks. However, the orientation of this paper is quantitative, based on simulations with the Federal Reserve Board's linked Multi-Country Model (MCM). Simulations were run over the four-year period 1979-1982, comparing the model's prediction of what has happened since the 1979 oil price shock with its prediction of what would have happened if the world oil price had remained unchanged in real terms at its end-1978 level.

The features of the model essential to an understanding of the simulation results are described in Section 2. This section outlines the recently constructed domestic oil and OPEC sectors added to the MCM and preliminary revisions of the exchange rate determination process. It also summarizes qualitatively the channels through which an oil price shock and OPEC investment behaviour affect domestic income, prices and exchange rates.

The simulation results are given in Section 3. The results generally were in the expected direction. The oil price shock raised prices and reduced real income and current account balances in each of the MCM countries. Real income in the United States was estimated to be 5 per cent lower in 1981 and the level of domestic prices 6 per cent higher than they would have been in the absence of the 110 per cent increase in the world oil price. Also, the dollar was 10 per cent higher on a weighted average basis in 1981, reflecting substantial appreciations against the mark and yen. Although U.S. oil imports rose more than those of either Germany or Japan, the dollar appreciated against those currencies partly because a substantially larger portion of the OPEC surplus was recycled initially into dollar assets and partly because the estimated parameters of the model yield asymmetrical responses of exchange rates to current account shifts across countries. The Canadian dollar depreciated only slightly and the pound appreciated against the dollar as Canada was only a small net importer of oil and the United Kingdom became a net exporter.

The effects of a substantial shift in OPEC's investment pattern on income and prices in the MCM countries were small relative to the impacts of the oil price increase itself. However, the exchange rate effects of the investment shift were significant. We considered what would happen if OPEC doubled the shares of its surplus (derived from the 1979-80 oil price increase) invested in mark, yen, sterling and Canadian dollar assets -- implicitly reducing the share invested in dollar assets (including Euro-dollars) from roughly 45 per cent of the total to 15 per cent. This shift lowered the simulated appreciation of the weighted-average dollar from 10 per cent to 3.5 per cent, again with most of the change against the mark and yen.

We also considered what would have happened if OPEC imports had grown at a faster rate (relative to the growth of OPEC export revenues) than they did after the 1973 oil price shock. This adjustment effectively lowered the predicted increase in OPEC's 1982 trade surplus attributable to the oil price increase from $65 billion to $21 billion. It also reduced the effects of the oil price shock on the current accounts, incomes and exchange rates of the MCM countries. Current accounts fell by less in all countries because of increased exports to OPEC. The negative impact of the oil shock on GNP was reduced by as much as 1 to 2 percentage points in most countries. Also, because of the current account movements and the decline in OPEC's surplus (which was invested heavily in dollar assets), the mark, yen and Canadian dollar depreciated less and the pound appreciated more against the dollar.

Finally, for several reasons we stress that these results -- particularly the quantitative estimates -- are tentative. First, the exercise we have undertaken is hypothetical: it assumes that OPEC would shift its investment pattern for exogenous (e.g., political) reasons, without being concerned about changes in the return on its international financial assets that the shift induced. Second, underlying assumptions about policy reactions in the MCM countries may not be completely realistic. The simulations assume no change in the domestic economic policies of the countries investigated in response to the oil price shock, but do allow for normal "smoothing" exchange market intervention by non-U.S. central banks, based on their average responsiveness to exchange rate changes over the past seven years. And third, parameters in some sectors of the model employed are preliminary and subject to a fairly wide error range, particularly in the area of exchange rate determination.

2 STRUCTURAL FEATURES OF THE MODEL

This section summarizes the features of the MCM essential to understanding the simulation results that follow. After a brief overview of the model, we outline: (i) the newly constructed oil consumption and trade sectors that have been added to the various country models; (ii) the OPEC sector; and (iii) the recently revised exchange rate determination properties of the MCM.

2.1 Overview of the MCM[1]

The MCM is a medium- to large-scale quarterly econometric model of five countries -- the United States, Canada, Germany, Japan and the United Kingdom -- as well as an abbreviated rest-of-world sector. The single-country models vary in size from roughly 200 to 300 behavioural equations and identities each, including fully developed domestic expenditure sectors, price and wage determination, money markets and international transactions sectors. Since the focus of the MCM is on international linkages, particular attention is paid to international transactions and the determination of exchange rates. Trade flows are determined bilaterally and service account and direct investment flows multilaterally. Four bilateral exchange rates (the C$, DM, yen and pound against the dollar) are determined in asset market equations. The rest-of-world sector includes aggregate trade, price and activity (industrial production) equations.

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[1] The original version of the MCM is described fully in Stevens et al (forthcoming), and more briefly in Berner et al (1977).

2.2 Oil Sector

The original MCM has recently been extended to model explicitly oil prices and quantities.[2] We focus on two distinct types of adjustment that follow an oil price shock. One is through the balance of payments -- we wish to explore what happens as the economy adjusts in the face of increased nominal oil imports. The MCM was built largely to model this sort of event, so this aspect of the problem is given high priority. The other adjustment is the response of domestic output and prices to a change in the relative price of energy. In the long run this is probably more important than the balance of payments problem; it is correspondingly harder to model empirically.

Two basic considerations have guided the specification of the oil model; both are dictated by limitations of data and other resources. The first is that the demand for oil has been specified directly -- as a function of real income and the relative price of oil -- rather than derived from total energy demand and relative energy prices. The second is that the basic theoretical structure of the MCM has been taken as given. Prices and quantities have been disaggregated into oil and non-oil components as appropriate within that structure, but no major changes in the structure are made.

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[2] The model and estimation results summarized here are presented in detail in Tryon (1981).

The prototype oil sector for an MCM country model is shown in Table 1. Equation (1) is a behavioural equation describing the demand for oil as a function of the relative price of oil and real income; the price of oil is assumed to be exogenous. Equation (2) is an identity deriving imports of oil, in physical units, given consumption, exports, stockpiling, and domestic production. The last three are assumed to be exogenous; in some of the MCM countries they are policy variables, and in any event are very difficult to model econometrically.

Equations (3) and (4) are bridge equations (quasi-identities) linking oil imports and exports in physical units to balance of payments (BOP) imports and exports in value terms. Physical oil trade flows are converted to local currency values using an exogenous oil price; this bridge equation allows for measurement errors, shipping lags and the like. The basic oil price used here is the average OPEC contract price; this is assumed to be set by OPEC. Where appropriate, domestic wholesale prices and export and import unit values of petroleum are used in estimation to allow for quality differentials and different national pricing strategies. In simulation all prices are assumed to move proportionately with the OPEC price.

A major complication in modelling oil in the MCM is that trade flows in the model are disaggregated by country but not by type of good. To be fully consistent with this framework, oil and non-oil trade flows among all the MCM countries would

TABLE 1

PROTOTYPE OIL SECTOR FOR MCM COUNTRY MODEL

Domestic Oil Demand

(1)	COL	=	f(POL/(P·ER), GNP)	behavioural equation
(2)	MGOL	=	COL + XGOL + SOL - QOL	identity
(3)	MGOLV	=	f(POL/ER·MGOL)	quasi-identity
(4)	XGOLV	=	f(POL/ER·XGOL)	quasi-identity
(5)	PMG	=	f(FPX/ER, POL/ER)	quasi-identity
(6)	P	=	f(W, PMG, CU, POL)	behavioural equation
(7)	PXG	=	f(W, PMG, CU, POL)	behavioural equation

where

COL = Domestic consumption of oil, barrels/day
POL = OPEC average oil price, $/barrel (exogenous)
P = Domestic price level
ER = Exchange rate, $/domestic currency
GNP = Real gross national product
MGOL = Total imports of oil, barrels/day
XGOL = Total exports of oil, barrels/day (exogenous)
SOL = Domestic oil stocks, barrels (exogenous)
QOL = Domestic oil production, barrels/day (exogenous)
MGOLV = Total imports of oil, current value
XGOLV = Total exports of oil, current value
PMG = Import price level
PXG = Export price level
FPX = Index of foreign export prices (in $)
CU = Capacity utilization

have to be modelled separately.[3] But since oil trade is small relative to total trade among the five MCM countries, we did not attempt to disaggregate the existing bilateral trade equations in the model. Instead, oil exports and imports are modelled only in the aggregate for each country. Total exports and imports for each country are adjusted to avoid double counting of oil trade, but another problem remains. To the extent that the estimated price elasticities in the bilateral trade equations are biased by the aggregation of oil and non-oil trade, the simulation results will be in error. This problem was not judged to be serious.

Oil trade is exogenous in physical terms except for imports from OPEC, which are determined residually by equation (2). This is a strong assumption but is consistent with a view of the world oil market in which OPEC sets the world price and adjusts output to maintain that price. Production in non-OPEC countries is assumed to be either at full capacity (for private production) or determined by government policies which are independent of the market price. The value of non-OPEC oil trade does, however, move with the price of oil.

Prices in the MCM are determined in a cost-plus-variable-markup framework. The price of oil enters both because oil is an intermediate input and because oil is a component of final output. The import unit value is determined by a bridge equation linking it to a trade-weighted average of export unit values and the price of oil (equation (5)). There are behavioural equations to determine PXG and P. Costs are represented by wages and the prices of intermediate inputs

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[3] At present there are five country models in the MCM: Canada, Germany, Japan, the United Kingdom and the United States, and a rest-of-world (ROW) sector. For this project the ROW sector was divided into OPEC and others.

(non-oil imports and oil), and the variable markup is a function of capacity utilization. For export prices, foreign variables (not shown) also affect the markup. There are only two domestically produced goods in an MCM country, exports and a non-traded good; domestic intermediate inputs other than oil do not appear. Since the price level P is the deflator for domestic absorption, which includes imports of final goods, there is an additional reason for PMG and POL to be included in the price equation. (POL enters separately from PMG because the weight of oil as an input and a consumption good may differ from that of non-oil imports. The log-linear specification used in estimation allows the aggregate PMG to be used instead of a non-oil import unit value index.)

There is no direct link between oil prices and supply in the MCM; output is determined by the interaction of aggregate demand and expected output (the discrepancy is partially buffered from inventories). Thus there is no binding supply constraint on the level of output that might be affected by supplies of inputs. There is, however, an indirect link through the capacity utilization variable, which is defined as actual over potential output and is determined by an implicit production function. Capacity utilization affects aggregate demand directly through inventory demand and indirectly through its effect on prices.

The theoretical structure of the present MCM contains a strong separability assumption which has the effect of making domestic productive capacity independent of the supply of imported intermediates. In this context it would seem appropriate to relax this assumption and include oil (and perhaps other intermediates) in the production function. Equation (14) shows such an equation for capacity utilization: depending on the production function chosen, oil prices might appear in the factor demand equation as well. However, obtaining both a consistent theoretical specification and satisfactory empirical estimates of such a production process is very difficult, and this part of the project has not been completed.

This oil model was estimated for each of the five countries in the MCM using quarterly data. Data for physical oil trade, consumption, production, and stockpiling were taken from the CIA International Energy Statistical Review; data on nominal oil trade and oil prices are from national sources. The equations were estimated using OLS, with an iterative correction for first-order autocorrelation. Given our assumption that the oil price is exogenous and given the theory of price determination in the MCM, a simultaneous equation method is not required.[4] Distributed lags were fitted with Almon polynomials. The complete estimation results are given elsewhere; in this section we summarize the major findings.[5] Equation (1) was estimated in log-linear form, with a short (four-quarter) lag on the price terms and the income elasticity was constrained to 1.0 over the 1975Q1-1980Q4 period (except for Canada, 1973Q1-1980Q4). The estimated total price elasticities are as follows:

Canada	-.192
Germany	-.313
Japan	-.198
United Kingdom	-.411
United States	-.248

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[4] Since real income is simultaneously determined with oil consumption in the full model, this is not strictly true; we assume that this effect is unimportant.

[5] See Tryon (1981).

The short lag length on prices was selected to accommodate the empirical reality that in the period following the first major price shock (1975 to 1978), oil consumption increased, essentially in line with income, in all the countries in our model. While some investigations have fitted long (7- to 8-year) lags to the price term in oil consumption functions (see Jacobson, Loftin and Thurman (1981)), our results were that plausible long lag distributions could only be obtained by imposing zero constraints and that these constraints could be rejected by the data. The unconstrained price lags are generally U-shaped, with a moderate initial impact dropping off to zero after one or two years and then becoming much stronger as the lag length increases. This appears to result from two essentially fortuitous correlations: between the 1979-80 decline in consumption and the 1974 price shock, and between the recovery of oil consumption in 1975-78 and the decline in real oil prices in the late 1960s.

Given the choice of a short price lag, the sample period was chosen to include only the second oil shocks since there is some evidence that the short-term price response in 1979-80 was greater than in 1974-75. Formal tests for structural change were inconclusive, but since the MCM is used for forecasting and current policy analysis, we chose to focus on this period. The constraint on the income elasticity was imposed on a priori grounds.

The price equations were also estimated in log-linear form. In all countries except Japan, both the aggregate import unit value and the oil price are significant in explaining the domestic price level; in Japan the oil price only affects domestic prices indirectly. The oil price typically enters with a one- or two-quarter lag into the price level in these equations. The estimated partial elasticities of the aggregate price level with respect to oil prices are as follows:

Canada:	
Impact	.018
Steady state	.079
Germany	.043
Japan	.099
United Kingdom	.056
United States	.044

Thus, a 10 per cent increase in world oil prices raises the price level by almost 1 per cent in Japan, around 0.5 per cent in Germany, the United Kingdom and the United States, and 0.2 per cent in Canada in the short run (0.8 per cent in the long run), apart from secondary adjustment. The effects on export prices are similar.

2.3 OPEC Sector

A small model of OPEC, consisting of the equations listed in Table 2, was added to the MCM as part of this project.

Equation (8) defines OPEC exports as the value of oil imports from OPEC by the MCM countries. (We ignore non-oil OPEC exports.) Oil imports from OPEC by MCM countries are determined by subtracting exogenous non-OPEC imports from the total for each country. Imports from OPEC by non-MCM countries are exogenous in physical terms. This procedure slightly overstates the response of nominal OPEC exports to a change in oil prices because there is no change in quantities exported to ROW, and because all OPEC exports are treated as oil.

Equation (9) was estimated in log-linear form with a twelve-quarter lag on OXGV over the 1972Q4-1980Q1 period. The sum of the lag coefficients is 0.937, which implies that given a unit percentage increase in export earnings, OPEC will

TABLE 2

OPEC SECTOR MODEL

$$(8)\quad OXGV = POL \cdot \sum_{i=1}^{5} (MGOL_i - MGOLX_i) + POL \cdot MGOL$$

$$(9)\quad OMGV = f(OXGV)$$ behavioural equation

$$(10)\quad OCAB = f((OXGV - OMGV),\ ONW \cdot URS,\ OXGV,\ TIME)$$ quasi-identity

$$(11)\quad ONW_t = \sum_{i=0}^{t} OCAB_{-i}$$ identity

where

OXGV = OPEC goods exports, in dollars

POL = Price of oil, dollars per barrel

$MGOL_i$ = Total oil imports in barrels, MCM country i

$MGOLX_i$ = Imports of non-OPEC oil in barrels, MCM country i (exogenous)

MGOL = Oil imports from OPEC in barrels, rest of world (exogenous)

OMGV = OPEC goods imports in dollars

OCAB = OPEC current account, in dollars

ONW = OPEC net financial wealth (cumulated current account)

URS = U.S. Treasury bill rate

TIME = Time trend

after three years come close to raising imports by the same percentage. But this does not imply that trade will balance -- because OPEC has run a trade surplus throughout this period, an increase in export earnings leads to an increased nominal surplus.

Equation (10), which was estimated using annual data, explains the OPEC current account as a function of the trade surplus and proxy variables for: (i) investment income (the U.S. Treasury bill rate times the cumulated OPEC current account; and (ii) royalty payments (export earnings) and imports of services plus repatriated earnings (a time trend).

The OPEC submodel is linked to the rest of the MCM through oil imports (as described above), goods exports, and the exchange rate equations. OPEC goods imports are allocated among the MCM countries by a simple exogenous share matrix.[6] This allows us to capture, if only in a crude way, some of the recycling of OPEC oil revenues. Recycling through international capital flows is modelled in the individual country exchange rate equations, as discussed below.

2.4 Exchange Rate Determination

The simulations we report in this paper are based on a preliminary revision of the exchange rate determination properties of the MCM. In the original version of the MCM, the exchange rate was determined implicitly as the price that cleared the balance of payments. Equations for each of the elements of the balance of payments were estimated as functions of the exchange rate and the exchange rate adjusted to achieve stock-flow equilibrium in the international accounts. The original approach is now being revised, partly because it yields implausible simulation properties and partly because of severe problems encountered in attempting to re-estimate private capital account equations.[7]

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[6] Since OPEC is also included in the original ROW sector of the MCM, it is again necessary to adjust the totals to avoid double counting. The result is that the increment in OPEC imports that results from a simulated change in oil prices is allocated by the share matrix. The original ROW trade equations are not directly affected by oil price changes.

In the revised approach, each of the four bilateral exchange rates is determined in an explicit exchange rate equation. The equation is derived from net foreign asset demand equations and is consistent with the portfolio balance approach to exchange rate determination. In essence, the revised approach involves inverting the net private capital account equation to determine the exchange rate; net private capital flows are then identified by the balance of payments equilibrium condition. This approach allows us more readily to analyze exchange rate behaviour in simulation exercises.

The derivation of the prototype exchange rate equation is given in Table 3. Equation (12) is the private capital account equation in stock form. This equation determines domestic private stock demand for foreign portfolio assets net of foreign private demand for domestic portfolio assets as a function of the expected relative returns on those assets and domestic and foreign wealth.[8] The expected relative return

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7. The problems encountered in the original model are described in Stevens et al (1980); the preliminary revisions are given in Hooper, Haas and Symansky (1981).

8. One problem with implementing this model empirically is that foreign assets may include substantial non-dollar assets. However, the currency denomination of foreign assets generally is not given in balance of payments data. The next phase of revision to exchange rate determination in MCM will involve testing weighted average (multilateral) as opposed to bilateral exchange rate equations.

TABLE 3

DERIVATION OF PROTOTYPE EXCHANGE RATE EQUATION

(12) $NFAP = f(RP, NW, FNW)$

(13) $RP = \log ER^* - \log ER + RS - URS$, where $RS - URS = -FP$

(14) $RP = f(NW, FNW, NFAP)$

(15) $\Delta NFAP = CAB - \Delta NFAG$

(16) $NW = \sum_{t=0} DEF_{-t} + K + \sum_{t=0} CAB_{-t}$

(17) $FNW = \sum_{i=1}^{4} (ER_i \cdot NW_i) + ONW$

(18) $\log ER^* = f(\overline{UP}-\overline{P}, (\Delta\overline{UP})^* - (\Delta\overline{P})^*, \sum_{t=1} CAB_{-t})$

(19) $\log ER = f(\overline{UP}-\overline{P}, (\Delta\overline{UP})^* - (\Delta\overline{P})^*, \sum_{t=1} CAB_{-t},$
$RS - URS, NW, FNW, NFAP)$

where

NFAP = Private net foreign assets
RP = Risk premium
NW = Domestic net worth
FNW = Foreign net worth
ER = Spot exchange rate ($/domestic currency)
ER* = Expected exchange rate
RS = Short-term (3-month) interest rate, URS = U.S. rate
FP = Forward premium
CAB = Current account balance
NFAG = Official net foreign assets
DEF = Government budget deficit
K = Domestic fixed private capital stock
ONW = OPEC wealth (in dollars)
$\overline{P}$ = Log of equilibrium price level (moving average of actual price level)
$(\Delta\overline{P})^*$ = Expected inflation rate (distributed lag on actual rates)
$\overline{UP}$ = $\overline{P}$ for the United States

on domestic assets is defined in equation (13) as the sum of the expected appreciation of the domestic currency against the dollar plus the domestic minus foreign (U.S.) interest differential. That variable is also labelled the risk premium -- the difference between the expected change in the exchange rate and the forward premium (as defined by the interest differential).

By rearranging equation (12), the risk premium is expressed as a function of domestic and foreign wealth and the stock of net foreign assets (equation (14)). From the balance of payments identity (15), changes in the stock of net foreign portfolio assets held in private portfolios are determined by current account flows and official intervention. Private domestic wealth (16) is determined by cumulative budget deficits, investment and current account flows; private foreign wealth (17) includes the sum of domestic wealths in the other four MCM countries plus OPEC wealth, as determined by cumulative OPEC current account flows in equations (8) through (11).

In a world of imperfectly substitutable assets and risk-averse portfolio managers, changes in the risk premium represent changes in the premium that asset holders demand on the expected return to domestic assets relative to foreign assets in order to accommodate exogenously induced shifts from desired portfolio positions at existing rates of return. Consistent with the portfolio balance model, from equations (14) through (17) it should be clear that for given portfolio preferences, the risk premium is ultimately determined by changes in the relative supplies of assets as determined by domestic and foreign government budget deficits, private domestic investment, current account positions and official intervention.

From equation (13), assuming unchanged exchange rate expectations and interest rates, a change in the risk premium induces an equal change in the log of the spot exchange rate in the opposite direction. However, the spot rate also moves in response to shifts in interest rates and exchange rate expectations. The expected exchange rate is defined in equation (18) as a function of equilibrium relative prices, relative expected inflation rates and the lagged cumulative current account balance. The first two terms tie down the current level and expected future path of the nominal exchange rate and the third identifies shifts in the expected real exchange rate.[9]

The exchange rate equation is derived by substituting (18) into (13) and the resulting equation into (12) and solving for logER. The resulting equation (19) expresses the exchange rate as a function of the three determinants of exchange rate expectations, the interest differential and the determinants of the risk premium.[10]

We can now identify the various channels through which an oil price shock and OPEC investment behaviour affect the exchange rate. The immediate impact of an oil price increase is to: (i) increase domestic price levels, inflation rates and (possibly) interest rates; (ii) reduce the current account and wealth of countries that are heavily dependent upon imported oil; and (iii) raise OPEC wealth. To the extent that prices and inflation in other MCM countries rise more than prices and inflation in the United States, their currencies will depreciate against the dollar through the impact on exchange rate expectations. Their currencies will also tend to appreciate if their domestic interest rates rise more than U.S. rates. The decline in the current account induces a depreciation through a change in expectations about the real exchange rate, and possibly through an increase in the risk premium on domestic assets, depending upon OPEC's portfolio preferences.

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[9] The current account is assumed to provide information to the market about shifts in the equilibrium real exchange rate. The announcement of a positive CAB, for example, implies that a sustained increase in the real exchange rate (as defined by ER·P/UP) is required to return CAB to equilibrium. This variable is lagged one quarter to reflect the lag with which it is announced to the market. The expectations hypotheses underlying (17) are discussed in detail in Hooper and Morton (1980).

[10] Since several of the variables on the right-hand side of equation (19) are endogenous with respect to the exchange rate, simultaneous equation techniques were used in estimation. In particular, instrumental variables were employed for NFAP, and in some cases RS and URS.

A decline in a country's current account due to higher oil imports has at least two effects on the risk premium.[11] First, it reduces the domestic net foreign asset position (requires foreign residents to hold additional domestic assets to finance the current account deficit), thereby raising the risk premium and causing the home currency to depreciate. Second, it also raises foreign (OPEC) wealth, which potentially raises demand for domestic assets and diminishes the home currency depreciation. In the extreme, if OPEC has a strong preference for assets denominated in the home currency and places all of its investable surplus following an oil price hike into those assets, the home currency could appreciate substantially despite a large decline in that country's current account position.[12] OPEC's preferences are captured in the coefficient on the OPEC component of the foreign wealth term defined in equation (17). The effects of shifts in OPEC's investment strategy are simulated by shifting that coefficient.

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[11] We assume here that OPEC's imports from the country in question are slow to catch up with its exports of oil to that country. Of course, changes in the current account and its effects discussed below will vary with the assumed rate at which OPEC absorbs its surplus by raising its imports. Countries that are net exporters of oil will be affected in the opposite direction.

The empirical implementation of the revised exchange rate determination process is still at a preliminary stage. Initial estimation results have been promising, but further work is needed.[13] Estimated coefficients on the expectations terms (relative prices, inflation rates and cumulative current account balances) and interest differentials generally are statistically significant with expected signs and plausible magnitudes. Coefficients on relative price levels, interest rates and inflation rates generally are in the neighbourhood of unity: a one per cent increase in foreign relative to domestic prices, or a one percentage point increase in the domestic minus foreign interest differential will cause the exchange rate to rise (domestic currency to appreciate) by roughly one per cent. Coefficients on the cumulative current account expectations variables are summarized below in Table 4a.

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12. To the extent that risk premium movements dominate the behaviour of the exchange rate they will be offset to some degree by intervention reaction functions that have been built into the MCM. These functions generally are either of a leaning against the wind or target exchange rate variety, so that a decline in the risk premium and rise in the exchange rate due to heavy OPEC investment inflows will be partially offset by an increase in official holdings of foreign assets.

13. See Hooper, Haas and Symansky (1981) for a description of preliminary estimation results.

TABLE 4a

IMPACT OF A $1 BILLION-EQUIVALENT DECLINE IN OWN-COUNTRY CUMULATIVE CURRENT ACCOUNT ON EXCHANGE RATE (through expectations)[14]

Currency (i)	Change in $/i Exchange Rate
German Mark	-.6%
Japanese Yen	-.2%
Canadian Dollar	-.3%
UK Pound	-.2%

The estimation of plausible coefficients on the risk premium determinants has been more problematical. Wealth and net foreign asset variables in stock form generally yielded insignificant coefficients, often with the wrong sign. When these variables were expressed in first differences (flow terms), correct signs and plausible magnitudes were obtained, but the estimates still are at best only marginally significant. We have concluded tentatively (pending further estimation work) that risk premiums are transitory phenomena. This could be explained behaviourally by portfolio preferences that are rigid in the short run but flexible in the long run. As time goes by following a shift in relative asset supplies, substitutability considerations become less important and

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14. In the Japanese case the cumulative trade balance performed better and was employed in place of the cumulative current account. In the Canadian case the cumulative basic balance was used. In the German case the addition of the U.S. cumulative current account significantly improved the equation (it did not in the other cases). The impact of a $1 billion decline in the cumulative U.S. current account is a 0.4 per cent appreciation of the mark.

expected relative return considerations more important in determining investment decisions. This view draws some support from two sources: (i) other empirical work that has failed to find evidence of sustained, significant risk premiums,[15] and (ii) anecdotal market evidence. With respect to the second source, foreign exchange traders commonly observe, for example, that a large order placed in a "thin" market is capable of moving the rate substantially for a while at least, but that as the market broadens, the initial movement in the rate is likely to be reversed as the initial order is absorbed by a wider set of asset holders.

In any event, the simulation properties of the preliminarily revised model are such that a one-time shift in OPEC's investment strategy (portfolio preferences) will have only a transitory impact on the exchange rate through the risk premium. Table 4b gives the impacts of a one-time $1 billion-equivalent shift of OPEC investments out of assets denominated in each of the non-dollar MCM currencies into assets denominated in dollars. The impact of the one-time shift is

TABLE 4b

DIRECT RISK PREMIUM EFFECT OF A $1 BILLION-EQUIVALENT SHIFT IN OPEC INVESTMENTS FROM CURRENCY i TO DOLLARS

Currency i	Change in $/i Exchange Rate (one quarter only)
German Mark	- .2%
Japanese Yen	-1.3%
Canadian Dollar	- .3%
UK Pound	- .3%

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[15] See, for example, Dooley and Isard (1979) and Frankel (1979).

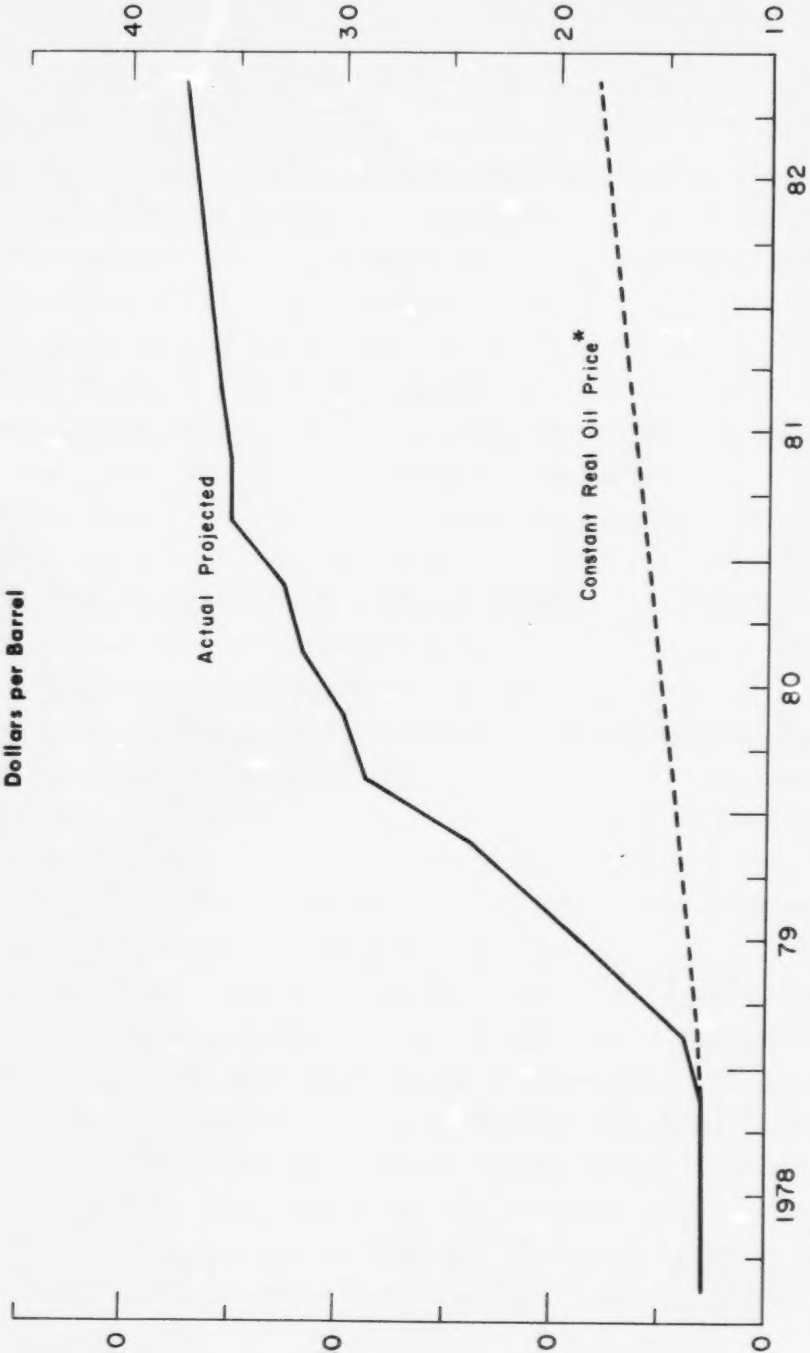
temporary, lasting for one quarter only, with the $/i exchange rate returning thereafter to its original level.

3 SIMULATION RESULTS

Four sets of simulations were run over the 1979Q1-1982Q4 period. Each involved comparing the model's prediction of what would have happened over this period if OPEC's prices had remained at their 1978 average level in real terms, with its prediction of what would happen given the actual path of oil prices to date, under alternative assumptions about the distribution of OPEC's surplus and the rate of absorption of that surplus. The oil price assumptions underlying all of these simulations are illustrated in the following figure. The dashed line depicts the oil price held constant in real terms at its 1978 level and the solid line gives the actual path of the oil price through mid-1981 and held constant in real terms thereafter. As illustrated by the difference between the solid and dashed lines, the price shock was spread over a two-year period from 1979Q1 to 1981Q1, with the full shock eventually amounting to about a 110 per cent increase in the oil price.

The first three sets of simulations involved alternative assumptions about the pattern of OPEC's investment across assets denominated in different currencies. These assumptions are given in Table 5. The first set of simulations constrained OPEC investment throughout the simulation period to the actual pattern observed in 1980 (column 1). The second and third sets assume, respectively, a 100 per cent increase and a 100 per cent decline in the mark, yen, Canadian dollar and pound shares, with the balance being taken out of or added to the shares in U.S. dollars. The three alternative

OIL PRICE ASSUMPTIONS
Average OPEC Contract Price
Dollars per Barrel



* At 1978 level

TABLE 5

OPEC INVESTMENT PATTERN ASSUMPTIONS
(Distribution of OPEC investment (flow) by currency denomination of asset)

	Simulation 1 Actual (1980) shares*	**Simulation 2** Reduced shares in dollars	**Simulation 3** Increased shares in dollars
Mark	17%	34%	0%
Yen	9%	18%	0%
Canadian dollar	1%	2%	0%
Pound	5%	10%	0%
U.S. dollar	47%	15%	79%
Other	21%	21%	21%

* Compiled from BIS and OECD publications and various news accounts. 1980 shares are based on currency denomination of OPEC holdings, not geographical location of those holdings.

investment patterns were implemented so that they affected only the investment (flow) of the addition to OPEC financial wealth resulting from the oil price increase. The distribution of the stock of OPEC investments in place prior to the oil price shock was not altered. This was accomplished by subtracting from the OPEC wealth variable (ONW) in each exchange rate equation an exogenized baseline path for ONW, and then adjusting the coefficients on ONW to reflect the alternative share assumptions listed in Table 5.

The fourth set of simulations involved accelerating the rate at which OPEC absorbs its surplus into higher imports. To achieve this, the distributed lag coefficients on OPEC exports in the OPEC import equation were adjusted to equate imports with exports within three years. As a result of this adjustment, the oil-price-shock-induced increase in OPEC imports by 1982 was raised from about $90 billion (annual rate) under the original OPEC import equation to $140 billion under the accelerated equation. The increase in the OPEC trade balance by 1982 dropped from $65 billion to $21 billion.

Before we turn to the results, the hypothetical nature of this exercise must be stressed: it is based on the assumption that OPEC would shift its investment pattern for exogenous (e.g., politically motivated) reasons, without any regard to the changes in relative rates of return induced by those shifts. It also assumes that the investment shifts as well as the oil price shock itself, could have taken place without inducing a shift in domestic monetary, fiscal or exchange rate (intervention) policies. Monetary sectors in the MCM countries generally do not include interest rate reaction functions but do allow for some degree of flexibility of money growth in the face of real shocks. Government spending and tax rates are held exogenous so that tax receipts act as an automatic stabilizer. The models do include intervention (smoothing) reaction functions so that exchange rate changes induced by the oil shock and investment shifts are mitigated to some extent by official intervention.

The results of the four sets of simulations are summarized by country in Tables 6 through 11. The data in these tables give the impacts of the oil price increase over each of the four years of the simulation period, expressed in terms of the difference between the model's predictions under the two alternative oil price assumptions.

Impacts on OPEC trade and current account balances are given in Table 6. Under the "actual" OPEC investment assumption (column 1), OPEC exports in 1982 are predicted to have increased by more than $150 billion as a result of the oil price increase. This increase in OPEC's export value reflects the price inelasticity of oil consumption demand in oil-importing countries. The impact on the OPEC trade and current account balances peaks in 1980 and declines thereafter, reflecting the lagged positive response of OPEC imports to the increase in export revenue, and, to a lesser extent, the lagged negative response of oil consumption in MCM countries to the higher prices. The OPEC trade response is very similar in the three investment scenarios (columns 1 to 3), but is substantially different with accelerated absorption (column 4). In the latter case, the level of OPEC imports is much higher throughout, leading to smaller OPEC trade and current account surpluses. The total cumulative increase in OPEC's current account is only $155 billion, compared with around $250 billion in the other scenarios. As we shall see below, this difference has important implications for the exchange rates in oil-importing countries.

The remaining tables give for each MCM country the impacts of the oil price increase on real GNP, domestic price (absorption deflator), exchange rate, current account and net exports of oil. The effects of the oil price shock assuming OPEC's actual recycling pattern (column 1 in each table) can be summarized as follows.

Domestic price levels are higher and real GNP lower in all countries throughout the simulation period as a result of the oil price shock. Domestic prices are raised directly as a result of the oil price increase in all cases, and indirectly because of local currency depreciation in some cases. GNP falls because: (i) in countries that are net oil importers, the oil price increase raises the share of total domestic expenditure devoted to imports (given the price inelasticity of oil consumption) and reduces real net exports; (ii) declining demand in oil-importing countries depresses

TABLE 6

OPEC RESULTS: IMPACTS OF 1979 OIL PRICE INCREASE UNDER ALTERNATIVE ASSUMPTIONS ABOUT OPEC INVESTMENT PATTERN AND ABSORPTION RATES
(Changes resulting from price increase, in billions of dollars)

	Actual (1980) OPEC investment pattern (1)	Reduced OPEC investment in dollar assets (2)	Increased OPEC investment in dollar assets (3)	Actual (1980) investment pattern, accelerated OPEC absorption (4)
Exports				
1979	50.33	50.59	50.09	50.40
1980	125.41	127.95	122.94	126.58
1981	146.33	151.16	141.66	149.34
1982	151.98	158.54	150.55	159.98
Imports				
1979	3.99	4.00	3.98	6.25
1980	30.84	31.14	30.56	53.62
1981	62.54	63.85	61.25	106.49
1982	87.18	94.38	89.25	138.69
Trade balance				
1979	46.34	46.58	46.10	44.15
1980	94.57	96.81	92.38	72.96
1981	83.79	87.31	80.40	42.85
1982	64.80	64.16	61.30	21.29
Current account balance				
1979	40.65	40.89	40.43	38.41
1980	84.58	86.92	82.29	61.98
1981	81.50	86.56	76.62	36.01
1982	69.96	73.72	63.13	16.85

TABLE 7

GERMAN RESULTS: IMPACTS OF 1979 OIL PRICE INCREASE UNDER ALTERNATIVE ASSUMPTIONS ABOUT OPEC INVESTMENT PATTERN AND ABSORPTION RATES
(Per cent and level changes resulting from price increase)

	Actual (1980) OPEC investment pattern	Reduced OPEC investment in dollar assets	Increased OPEC investment in dollar assets	Actual (1980) investment pattern, accelerated OPEC absorption
	(1)	(2)	(3)	(4)
GNP (%)				
1979	- 0.02	0.02	- 0.07	0.01
1980	- 0.92	- 0.48	- 1.35	- 0.52
1981	- 1.47	- 0.22	- 2.74	- 0.42
1982	- 0.51	1.17	- 1.60	1.58
Prices (%)				
1979	1.12	1.09	1.16	1.13
1980	4.27	4.16	4.38	4.33
1981	6.51	6.29	6.71	6.59
1982	8.24	7.89	9.12	8.45
Exchange rate (%)*				
1979	- 0.23	0.21	- 0.66	- 0.24
1980	- 4.08	- 2.35	- 5.74	- 3.99
1981	-10.86	- 7.10	-14.41	- 9.65
1982	-16.83	-10.05	-24.45	-13.30
Current account (billions DM)				
1979	- 6.29	- 5.53	- 7.04	- 6.00
1980	-19.14	-14.66	-23.61	-16.07
1981	-25.85	-14.23	-37.89	-17.85
1982	-19.60	- 5.07	-30.18	- 1.99
Net exports of oil (billions DM)				
1979	- 9.55	- 9.41	- 9.70	- 9.57
1980	-27.21	-26.60	-27.81	-27.39
1981	-36.55	-35.05	-38.02	-36.51
1982	-46.50	-43.30	-53.10	-46.11

* Per cent change in dollar/d-mark; decline = depreciation of mark.

TABLE 8

JAPANESE RESULTS: IMPACTS OF 1979 OIL PRICE INCREASE UNDER ALTERNATIVE ASSUMPTIONS ABOUT OPEC INVESTMENT PATTERN AND ABSORPTION RATES
(Per cent and level changes resulting from price increase)

	Actual (1980) OPEC investment pattern (1)	Reduced OPEC investment in dollar assets (2)	Increased OPEC investment in dollar assets (3)	Actual (1980) investment pattern, accelerated OPEC absorption (4)
GNP (%)				
1979	- 1.56	- 1.32	- 1.78	- 1.52
1980	- 5.56	- 4.40	- 6.62	- 5.12
1981	- 3.95	- 3.28	- 4.32	- 3.11
1982	- 2.20	- 2.51	- 1.10	- 0.02
Prices (%)				
1979	3.68	2.91	4.45	3.66
1980	13.20	9.34	17.51	12.85
1981	10.07	6.36	14.26	9.37
1982	8.80	5.75	11.50	5.81
Exchange rate (%)*				
1979	- 6.25	- 3.59	- 8.77	- 6.21
1980	-26.24	-15.09	-36.45	-25.35
1981	-23.70	-10.34	-35.64	-21.08
1982	-20.36	- 9.27	-30.57	- 8.18
Current account (trillion Y)				
1979	- 1.08	- 0.96	- 1.19	- 1.05
1980	- 3.95	- 3.09	- 4.74	- 3.55
1981	- 3.13	- 2.57	- 3.55	- 2.14
1982	- 1.18	- 1.84	- 0.04	0.45
Net exports of oil (trillion Y)				
1979	- 2.48	- 2.23	- 2.23	- 2.48
1980	- 6.24	- 5.03	- 5.03	- 6.17
1981	- 5.31	- 4.15	- 4.15	- 5.10
1982	- 7.09	- 6.80	- 6.80	- 6.56

* Per cent change in dollar/yen; decline = depreciation of yen.

TABLE 9

CANADIAN RESULTS: IMPACTS OF 1979 OIL PRICE INCREASE UNDER ALTERNATIVE ASSUMPTIONS ABOUT OPEC INVESTMENT PATTERN AND ABSORPTION RATES
(Per cent and level changes resulting from price increase)

	Actual (1980) OPEC investment pattern (1)	Reduced OPEC investment in dollar assets (2)	Increased OPEC investment in dollar assets (3)	Actual (1980) investment pattern, accelerated OPEC absorption (4)
GNP (%)				
1979	-0.01	0.02	-0.03	0.00
1980	-0.48	-0.22	-0.73	-0.30
1981	-1.43	-0.80	-2.07	-0.89
1982	-2.03	-1.25	-2.79	-1.08
Prices (%)				
1979	0.19	0.20	0.19	0.19
1980	1.50	1.59	1.40	1.53
1981	3.21	3.58	2.83	3.40
1982	4.22	5.09	3.53	4.85
Exchange rate (%)*				
1979	0.25	0.30	0.20	0.26
1980	-0.35	-0.19	-0.49	-0.28
1981	-2.13	-2.09	-2.13	-1.99
1982	-2.41	-2.68	-1.88	-2.15
Current account (billions C$)				
1979	1.00	1.07	0.94	1.05
1980	-0.03	0.53	-0.57	0.47
1981	-2.00	-0.97	-2.98	-0.89
1982	-1.96	-1.75	-1.91	-0.55
Net exports of oil (billions C$)				
1979	-0.18	-0.19	-0.17	-0.18
1980	-1.41	-1.47	-1.34	-1.45
1981	-2.20	-2.41	-1.99	-2.38
1982	-2.90	-3.54	-2.91	-3.58

* Per cent change in U.S. dollar/Canadian dollar; decline = depreciation of Canadian dollar.

TABLE 10

UNITED KINGDOM RESULTS: IMPACTS OF 1979 OIL PRICE INCREASE UNDER ALTERNATIVE ASSUMPTIONS ABOUT OPEC INVESTMENT PATTERN AND ABSORPTION RATES
(Per cent and level changes resulting from price increase)

	Actual (1980) OPEC investment pattern (1)	Reduced OPEC investment in dollar assets (2)	Increased OPEC investment in dollar assets (3)	Actual (1980) investment pattern, accelerated OPEC absorption (4)
GNP (%)				
1979	-0.43	-0.42	-0.44	-0.39
1980	-1.79	-1.70	-1.84	-1.32
1981	-3.35	-3.02	-3.57	-2.55
1982	-5.27	-4.58	-6.00	-5.26
Prices (%)				
1979	0.32	0.31	0.32	0.31
1980	2.36	2.35	2.38	2.31
1981	3.33	3.52	3.10	2.94
1982	2.00	2.39	0.67	0.39
Exchange rate (%)*				
1979	0.47	0.64	0.31	0.49
1980	2.01	2.34	1.71	2.44
1981	8.28	7.75	8.98	10.71
1982	17.58	17.16	22.79	26.95
Current account (billion £)				
1979	0.11	0.12	0.10	0.19
1980	1.93	1.73	2.18	2.79
1981	7.07	6.30	8.04	8.89
1982	6.73	6.77	7.39	8.44
Net exports of oil (billion £)				
1979	0.16	0.16	0.16	0.16
1980	0.79	0.78	0.80	0.75
1981	1.82	1.80	1.82	1.67
1982	2.08	2.14	2.14	1.93

* Per cent change in dollar/pound; decline = depreciation of pound.

TABLE 11

UNITED STATES RESULTS: IMPACTS OF 1979 OIL PRICE INCREASE UNDER ALTERNATIVE ASSUMPTIONS ABOUT OPEC INVESTMENT PATTERN AND ABSORPTION RATES
(Per cent and level changes resulting from price increase)

	Actual (1980) OPEC investment pattern	Reduced OPEC investment in dollar assets	Increased OPEC investment in dollar assets	Actual (1980) investment pattern, accelerated OPEC absorption
	(1)	(2)	(3)	(4)
GNP (%)				
1979	- 0.14	- 0.09	- 0.18	- 0.12
1980	- 2.07	- 1.70	- 2.44	- 1.76
1981	- 5.37	- 4.65	- 6.08	- 4.76
1982	- 7.55	- 7.16	- 8.06	- 6.86
Prices (%)				
1979	0.89	0.91	0.86	0.89
1980	3.93	4.15	3.71	3.94
1981	6.42	6.94	5.88	6.51
1982	8.13	9.04	7.46	8.64
Exchange rate (%)*				
1979	1.58	0.64	2.51	1.57
1980	9.08	4.55	14.03	8.60
1981	10.11	4.29	16.43	8.12
1982	9.88	3.49	16.65	2.81
Current account (billions U.S.$)				
1979	- 8.16	- 8.03	- 8.28	- 7.88
1980	-13.78	-11.64	-15.74	-11.34
1981	- 9.45	0.19	-18.50	- 3.25
1982	1.82	21.65	-17.44	15.31
Net exports of oil (billions U.S.$)				
1979	-11.28	-11.36	-11.21	-11.32
1980	-27.58	-28.44	-26.73	-28.23
1981	-31.41	-33.47	-29.35	-32.97
1982	-27.43	-30.38	-27.02	-30.98

* Per cent change, weighted average foreign currency value of the U.S. dollar (multilateral trade share weights); decline = depreciation of the U.S. dollar.

demand for the exports of other countries (especially with respect to Canadian exports to the United States); (iii) higher prices put upward pressure on interest rates (given relatively inflexible money or base money growth paths) and depress domestic investment and consumption; and (iv) in the U.K. case, the appreciation of the pound (as discussed below) depresses real net exports.

While the direction of price and income effects is consistent across countries, the magnitudes of these effects vary substantially. By 1982 German, Japanese and U.S. prices are roughly 8 per cent higher than they would have been in the absence of the oil price increase, compared with 4 per cent for Canada and 2 per cent for the United Kingdom. In the Canadian case, the difference is largely a result of a relatively lower coefficient on oil prices in the domestic price equation.[16] U.K. prices rise much less, largely because of the appreciation of the pound (discussed below).

With respect to GNP impacts, U.S. GNP declines the most (by 7.5 per cent in 1982), because the negative impact of the shift in expenditure to oil imports is augmented by a further decline in net exports as a result of the appreciation of the dollar (discussed below). U.K. GNP is affected in the same direction despite the United Kingdom's position as a net oil exporter, because of the appreciation of the pound. In Germany and Japan -- both net oil importers -- initial declines in GNP are partly reversed by the stimulus to net exports provided by substantial depreciations of their currencies.

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[16] Even so, the Canadian price impact still may be overstated. In implementing the simulations, we assumed that Canada's domestic producer-price of oil would rise by the same proportion as the world oil price. In reality, the Canadian domestic price was controlled and did not rise in line with the world price. Instead, the increase in the world oil price raised the Canadian government budget deficit by the amount of the net subsidies paid to hold down the domestic oil price. Hence, the actual impact on Canada's domestic price level could be somewhat lower than suggested by these simulation results.

Among the various exchange rate determinants discussed in Section 2, changes in current account positions and OPEC investment flows appear to be the most important factors underlying changes in exchange rates observed in the first set of simulations. The current accounts of all countries decline owing to increases in net oil imports, with the exception of the U.K. current account (which rises with U.K. oil exports). The negative impact on the U.S. current account is temporary, as the decline in U.S. GNP eventually depresses total import demand by enough to more than offset the increased value of oil imports. The mark depreciates against the dollar (by nearly 17 per cent in 1982) because the estimated effect of the decline in the cumulative German current account on exchange rate expectations exceeds that of the decline in the cumulative U.S. current account, and because a substantially larger share of the OPEC surpluses is recycled into dollar assets than into mark assets (see Table 5, column 1). The yen depreciates against the dollar for similar reasons. The relatively greater depreciation of the yen (than that of the mark) is partly due to the fact that the yen is expressed as a function of the Japanese cumulative trade balance (which declines more than the Japanese current account), and because the U.S. current account is not included in that equation. The Canadian dollar depreciates slightly because of the decline in the Canadian current account, while the pound appreciates, reflecting the improvement in the U.K. current account.

The effects of shifts in OPEC investment behaviour are shown in columns 2 and 3 of the tables. As discussed above, column 2 involves a 100 per cent increase and column 3 a 100 per cent decline in the shares of the increase in OPEC's surplus invested in non-dollar-denominated assets. The results are roughly symmetrical with respect to the "actual" case (column 1), so we focus on a comparison of columns 1 and 2, involving a shift out of dollars into other currency assets. The shift out of dollars, predictably, results in significantly smaller depreciations of the mark and yen against the dollar. The fact that these depreciations are not reversed completely suggests that while OPEC investment shifts can affect exchange rates significantly, they are dominated in the model by the effects of the oil-price-induced shifts in current accounts on exchange rate expectations. The Canadian dollar is not greatly affected by the investment shift because the share of OPEC investments in Canadian dollar assets was small to begin with. (Anomalous behaviour of the pound is yet to be explained.)

These exchange rate changes have the expected effects on domestic prices: the relative appreciations of the mark and yen against the dollar reduce the inflationary impact of the oil price increase in Germany and Japan, but augment the inflationary impact in the United States. The behaviour of GNP is not as transparent. Both German and Japanese GNP rise relative to the Simulation 1 results (although Japanese income eventually falls slightly), contrary to what one would expect based on the negative impact of the relative mark and yen appreciations on the real net exports of those countries. In the German case, domestic investment appears to have been stimulated by a decline in long-term interest rates associated with the relative decline in domestic prices. U.S. GNP does rise relative to the Simulation 1 results because the relative depreciation of the dollar stimulates net exports.

Finally, the results of the simulations involving an acceleration of OPEC absorption (column 4 in each table) generally conform to our priors. As compared with column 1 results, the increase in OPEC's imports raises current account balances and real GNP in all five MCM countries. The current account movements, as well as the relatively greater reduction of OPEC investment in dollar assets (as OPEC's surplus falls), reduce the depreciations of the mark, yen and Canadian dollar, and increase the appreciation of the pound. Hence, the U.S. dollar appreciates less on a weighted average basis. The exchange rate movements, in turn, reduce the inflationary impact of the oil price increase in Japan, Germany and the United Kingdom, but work in the opposite direction in the United States to raise the domestic inflationary impact.

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THE OIL PRICE INCREASE AND REAL EXCHANGE RATE CHANGES AMONG INDUSTRIAL COUNTRIES

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The views expressed in this paper are those of the author and do not necessarily reflect the views of the International Monetary Fund.

1 INTRODUCTION

The purpose of this paper is to estimate the change in real exchange rates among industrial countries needed to offset the longer run differential balance of payments effects of the 1973-80 oil price increases. In general, the net effect on the balance of payments of a country will depend on whether the deterioration in its balance of payments due to higher oil prices is greater than or less than the improvement in its balance of payments due to increased exports to and increased investment flows from the oil-exporting countries.[1] Within the group of industrial countries, the change in a country's real exchange rate will depend on the net effect of higher oil prices on its balance of payments relative to that of other industrial countries.

Experience has shown that large changes in oil prices within a short period of time result in large surpluses for the oil-exporting countries, the disposition of which will affect real exchange rates. Over time, however, as the surpluses of the oil-exporting countries fall, investment flows influence real exchange rates less and less. In the longer run, when the surplus of the oil-exporting countries can be expected to be fully absorbed, the predominant factors influencing the realignment of real exchange rates will be the net energy positions (the balance of trade in energy-related goods and services) of countries compared with their exports to the oil-exporting countries.

Analytically there are two parts to the derivation of the estimates of the real exchange rate changes needed to offset the effects of higher oil prices. It is first necessary to quantify the longer run differential balance of payments effects of higher oil prices. This is done by estimating for each industrial country the change in its balance of payments that can be attributed solely to higher oil prices. It is argued in Section 3 that the primary effect of higher oil prices on the balance of payments will be through the trade account, in the form of trade in energy. Energy balances are projected to 1985 to allow for lags in the adjustment of energy production and consumption to higher oil prices and in the absorptive capacity of the oil-exporting countries. Once the net balance of payments effects for each country have been estimated, the Multilateral Exchange Rate Model (MERM) is used to solve for the changes in real exchange rates among industrial countries that would offset these longer run differential effects of higher oil prices.

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[1] See Krugman (1980).

The MERM imposes a consistent framework within which the relative positions of different countries can be reconciled. An overview of its structure and how it is used in this application is presented in Section 2. In Section 3, the method used to quantify the impact of higher oil prices on the balance of payments is described. Using the estimates obtained therein, the model is solved for the requisite changes in real exchange rates. Conclusions are presented in Section 4.

2 OVERVIEW OF THE MULTILATERAL EXCHANGE RATE MODEL

The Multilateral Exchange Rate Model (MERM) is a Walrasian-type general equilibrium model designed for the purpose of estimating the effects of exchange rate changes on trade balances after a period of several years. A full description of MERM is given in the June 1981 issue of the IMF Staff Papers. Here, the main features of the model are summarized with emphasis on applicability to the present problem. A schematic representation of the equations of the model is provided in an Appendix for reference.

Assessing the differential impact among industrial countries of higher oil prices requires a multi-country model that takes into account the structure of production and demand in each country and that includes at least two traded goods (oil and non-oil). In MERM, six commodity groups, called goods, are distinguished and a consistent set of supply and demand equations incorporating the input-output structure of each country is specified. Based on the Standard International Trade Classification, the commodity groups are:

(1) Agricultural commodities (SITCs 0 & 1);
(2) Raw materials (SITCs 2 & 4);
(3) Mineral fuels (SITC 3);
(4) Semi-finished manufactures (SITCs 5 & 6);
(5) Finished manufactures (SITCs 7 & 8 & 9); and
(6) Non-traded commodities (commodities and services not traded).

Each good satisfies both intermediate and final demand, the amount demanded depending on activity variables and relative prices.

The demand system distinguishes between goods and products. A product is a good produced by a particular country. For example, German-finished manufactures and Japanese-finished manufactures are the same kind of good, but two different products. The model includes eighteen industrial countries and two regional groups of countries.[2]

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[2] The countries and groups of countries used in MERM are Australia, Austria, Belgium-Luxembourg, Canada, Denmark, Finland, France, the Federal Republic of Germany, Ireland, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, the United States, the oil-exporting countries, and the rest of the world.

There are, therefore, 2,020 (20 markets with 5 x 20 traded goods plus 1 non-traded good) product demand functions in MERM. The most important relative price effects on the demand side are those pertaining to price changes among products of the same kind of good. Changes in product prices shift demands for a particular good from higher price suppliers to lower price suppliers. The other important relative price effect results from the change in traded goods prices versus non-traded goods prices. Exchange rate depreciation (appreciation) raises (lowers) the prices of traded goods, shifting domestic demand toward non-traded (traded) goods.

The supply of each good produced by each country is simply a function of the prices of the six goods relative to their costs of production in the market of the producing country. The feedback effects of exchange rate changes onto domestic costs and prices are fully accounted for in the model. The magnitude of these feedback effects determines the change in the real exchange rate associated with any nominal exchange rate change. Since the present analysis focuses on the impact of higher oil prices on real exchange rates, the feedback effects will be suppressed when solving the model.

The model is closed by imposing the market equilibrium condition that the supply and demand for each product must be equal, and by constraining real output in each country to be constant. The latter constraint permits abstraction from price level changes among countries resulting from changes in output. Since output is held constant, the effect of relative price changes on the supply side is to shift resources from one sector to another, primarily between the non-traded and traded goods sectors in this application.

Estimation of the effects of higher oil prices on the balance of payments of industrial countries will be based on those factors that affect the supply and demand for energy (SITC 3): expected rates of economic growth, prices, and income elasticities, conservation policies, etc. Excess domestic demand for or supply of energy will be reflected in the effects on the balance of payments. These effects need to be offset by non-fuel transactions. Therefore, the desired changes in real exchange rates (relative prices) among the industrial countries are those that will bring about the change in competitive positions on non-fuel transactions that will offset the losses or gains on fuel transactions.

Two points should be noted. First, actual and expected growth rates have already been taken into account in determining the effects on the balance of payments. It is assumed, therefore, that economic policy is used to offset the effects of real exchange rate changes on activity levels. In other words, the real exchange rate changes are not allowed to further stimulate or depress output which would, in turn, affect the demand for energy. Second, it is assumed that real exchange rate changes among the industrial countries, per se, have no effect on the real price of oil.

Normally, the MERM is used to estimate the effects of exchange rate changes on trade flows, but if trade balance changes are known it can be used to solve for exchange rate changes that would result in the desired trade balance changes. The procedure for doing this is described in the article by Artus and Rhomberg[3] presenting the original MERM. In the present application two things differ from the general procedure. The feedback effects of exchange rate changes on domestic prices and costs are suppressed in order to solve for real exchange rate changes and, since fuel transactions are included in the effects on trade positions, the offsetting trade balance changes are achieved via non-fuel transactions.

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[3] See Jacques R. Artus and Rudolf R. Rhomberg, "A Multilateral Exchange Rate Model", IMF Staff Papers, vol. 20, November 1973, pp. 604-605.

3 THE EFFECTS OF HIGHER OIL PRICES ON THE BALANCE OF PAYMENTS

Higher oil prices affect industrial countries' balance of payments positions directly through their effects on trade in energy-related goods and services and indirectly through increased exports to and investment flows from the oil-exporting countries. In the longer run, the export earnings of the oil-exporting countries can be expected to be fully absorbed -- spent on goods and services from abroad -- and current investment flows would cease. Further, on the assumption that financial markets operate efficiently, there would be no net effect of the portfolio preferences of the oil-exporting countries on industrial countries' balance of payments positions, and hence on real exchange rates. Capital would flow among countries so as to equalize the risk-adjusted rates of return on investment, and any investment preferences of the oil-exporting countries would be counterbalanced by offsetting capital flows of other countries. Under these assumptions the major longer run effects of higher oil prices on industrial countries' external positions would depend on their net energy positions and the trade preferences of the oil-exporting countries. The net energy position of a country is defined as the balance on trade in energy-related goods and services. This consists mainly of trade in fuels (SITC 3) and shipping, transportation and passenger services. The balance on the latter service items is small in relation to that of fuels and, in this preliminary version of the paper, no attempt is made to estimate the effects of higher fuel prices on the net payments positions for these items.

In what follows the term energy balance(s) refers to the balance on trade in fuels (SITC 3), which affects only the trade account of the balance of payments. The method used to project the effects of higher oil prices on industrial country energy balances by 1985 relies on two sets of projections -- projections that assume no increase in the real price of oil since 1972 and projections that take into account increases in the real price of oil up to the third quarter of 1981. An analysis of pre-1973 trends in energy supply and demand motivates the assumptions upon which the 1972 real price of oil projections are based. The projections of energy balances that take into account the oil price increases through the third quarter of 1981 are based primarily on two published sources, the most recent country projections submitted to the IEA[4] and, for countries not covered in the IEA report, projections developed by the Workshop on Alternative Energy Strategies.[5] The projections from these two sources are derived within a global framework that ensures equilibrium in the world energy market. Nevertheless, some of the estimates now seem out of date and adjustments have been made where more recent developments indicate significantly different results

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4. International Energy Agency. Energy Policies and Programmes of IEA Countries, 1980 Review, OECD, Paris, 1981.

5. Workshop on Alternative Energy Strategies. Energy Supply-Demand Integrations to the Year 2000: Global and National Studies, ed. by Paul S. Basile, MIT Press, Cambridge, 1977.

than those projected by 1985.[6]

The effects on energy balances in 1985 due to higher oil prices are derived by estimating domestic demand for energy minus indigenous supply, under the two oil price assumptions. Excess domestic demand for (supply of) energy results in energy imports (exports), mainly imports (exports) of oil, gas, and coal.

The constant 1972 real oil price projections are intended to represent what energy balances would have been in 1985 if there had been no change in the real price of oil. While the large structural changes that have taken place since 1973 make any such estimate highly speculative, trends in the demand for and supply of oil prior to the oil price increase in 1973 may give a rough indication of what developments might have been in the absence of these price increases.

In retrospect, the 1960s were years of high economic growth accompanied by inexpensive and abundant sources of energy. Oil production increased at an annual rate of 6 to 7 per cent and the real price of oil fell steadily from the early 1950s until it reached a low point in 1970. Increases in the supply of oil during the 1960s accounted for nearly 62 per cent of the increase in total energy supplies for that period. As a consequence of the growth in oil supplies relative to other sources of energy, the share of oil in total energy demand increased from around 36 per cent in 1960 to slightly over 50 per cent by the time of the first large oil price increases in 1973.

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[6] Specifically, the projections of energy demand for the United States, Japan, and Germany were revised downward in light of the significant drop in oil consumption from 1979 to 1980. See Table 4a.

Apart from its relatively more abundant supply and falling real price, qualitative characteristics of oil also contributed to its increasing share in energy consumption. It was easier to extract, transport, and use than alternative energy sources, and for the increasing demand from motor vehicle use there were no viable substitutes.

These global developments were reflected in the trends in the demand for energy and in particular for oil in the individual industrial countries. Table 1 shows the elasticities of total energy consumption, oil consumption, and net oil imports with respect to the growth of GDP for the 1960-73 period. The elasticity of total energy consumption is greater than one for most of the industrial countries reflecting both the increasing energy intensity of these economies and the fall in the real price of oil during the 1960s. The substitution of oil for other energy sources is apparent from the oil consumption and net oil import elasticities which, for the majority of countries, are nearly 1 to 2 points higher than the elasticity of total energy.

Oil markets tightened in the early 1970s giving some indication that the period of stable oil prices was coming to an end. Several host countries renegotiated their contracts with the international oil companies and increased their posted prices. At the same time, the decline in the ratio of oil reserves to oil production, the decrease in major oil discoveries and the increased dependence on oil imports from "unstable" sources had not gone unnoticed in the oil-importing countries. Still, projections of energy demand and oil imports made prior to the 1973 oil price increase were based either on no change in the price of oil or on only small increases. And further, it was thought that energy demand would continue to grow more rapidly than GDP, with imported

TABLE 1

ELASTICITIES OF ENERGY CONSUMPTION WITH RESPECT TO GDP GROWTH (1)(2)
(unadjusted for relative price changes)

	Average 1960 to 1973		
	Total energy consumption	Oil consumption	Net oil imports
Canada	1.02	.98	0.00
United States	1.07	1.13	2.60
Japan	1.00	1.76	1.77
Germany	1.05	2.84	3.00
France	.96	1.94 (3)	2.42
Italy	1.51	2.42	2.30
United Kingdom	.68	2.31	2.10
Australia	1.20	1.57	-0.30
Austria	.99	2.30	4.80
Belgium	.97	2.20	2.30
Denmark	1.39	2.20	2.20
Ireland	.98	2.90	2.50
Netherlands	1.65	1.66	2.00
Norway	1.42	1.58	1.10
Spain	1.12	2.11	2.10
Sweden	1.17	1.67	1.50
Switzerland	1.24	2.48	2.30

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(1) The growth of energy consumption divided by the growth of GDP.

(2) Source: Energy Policies and Programmes of IEA Countries, 1980 Review. International Energy Agency; Energy Balances of OECD Countries, Paris: OECD; and International Financial Statistics, Washington: IMF.

(3) Average 1966 to 1973.

oil increasingly filling the energy gap. The pre-1973 evidence suggests that foreseeable price increases were not expected to be large enough to dampen very much the historical trends in demand.

On the demand side then, had there been no increase in the real price of oil, it would seem reasonable to project the demand for energy based on assumptions as to the growth of GDP and the elasticity of energy demand with respect to GDP. Projecting supply in the absence of an increase in energy prices is more problematical, since even in the face of unprecedented price increases, the trend growth in actual supplies has fallen below pre-1973 historical averages. The extent of this fall was, for the most part, not foreseen in the early 1970s.

In a survey of energy projections to 1985 by Brodman and Hamilton,[7] 78 studies prepared during the period 1969 through mid-1978 were reviewed chronologically. A Group of Thirty study[8] updates the Brodman-Hamilton survey through early 1980. The technique used in both these surveys was to array energy demand and supply projections chronologically in an attempt to observe patterns in these projections over time. Selected results from the Group of Thirty study, which covers more recent projections, are shown in Table 2. The table shows that there had been a steady downward revision over time in the two main factors determining energy demand, the growth of real GDP and the elasticity of demand for energy with

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7. Brodman, John R. and Richard G. Hamilton. "A Comparison of Energy Projections to 1985." IEA Monograph, OECD, January 1979.

8. Deagle, Edwin A. Jr; Mossavar-Rahman, Bijan; and Richard Huff. "Energy in the 1980s: An Analysis of Recent Studies." Group of Thirty Occasional Papers 4, New York: 1981.

respect to real GDP (unadjusted for price changes). These downward revisions explain most of the differences in projections of energy demand. The fall in the energy/GDP elasticity indicates that the demand response to price increases has been stronger than initially expected.

On the supply side, the historical projections displayed a somewhat different pattern. The highest supply estimates were made during the period immediately after the oil price increase, reflecting price elasticity optimism. Thereafter, estimates were revised downward until they fell below estimates of supply made prior to the oil price increase. The two major sources of error in the supply projections were overestimates of the supply of oil in the United States and of nuclear energy in almost all countries. Downward revisions to oil and NGL production in the United States accounted for half of the revision to oil and NGL production in the OECD, and expected development of nuclear capacity has not materialized on the scale previously envisioned, owing mostly to environmental concerns and the long lead times required to install nuclear plants.

As these data suggest, projecting supply based on pre-1973 trends would lead to higher supply estimates for the 1972 oil price projections than more recent projections which take into account the two major oil price increases -- the implication being that the price response is perverse. Rather than the price response being perverse, it would seem that energy supply, at least in the medium term, is determined more by technological factors than by behavioural factors. For example, drilling rates increased dramatically after the 1973 oil price increase and remained high, reflecting the behavioural response to higher prices. Nevertheless, discoveries, which had averaged about 68 billion barrels per

TABLE 2

SELECTED ENERGY PROJECTIONS TO 1985

A: Factors Affecting Demand Projections to 1985 (1)

	Averages of Projections	
Period of Projection	OECD: Annual rates of growth of real GDP 1970-1985	OECD: Energy/GDP elasticity 1970-1985 (unadjusted for price changes)
1972-1973	4.95	1.03
1974-1976	4.39	.87
1977-1978	3.75	.82
1979-1980	3.51	.71

B: Supply Projections for 1985 (2)

	Averages of Projections			
Period of Projection	OECD: Natural gas production (mmbdoe)	OECD: Oil and NGL production (mmbd)	United States: Oil and NGL production (mmbd)	OECD: Installed nuclear capacity (GWe)
1972-1973	15.2	21.0	12.1	530
1974-1976	18.3	22.5	13.0	430
1977-1978	14.3	16.9	10.6	271
1979-1980	13.6	15.0	8.9	218

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(1) Source: Group of Thirty, Occasional Papers 4, pp. 6-7.
(2) Source: Group of Thirty, Occasional Papers 4, pp. 8-11.

decade for the 1950s and 1960s, fell to 35 million barrels in the 1970s. The rate of discovery of super giant fields was more than 10 fields per decade in the 1950s and the 1960s; during the 1970s only two super giant fields were discovered. Even after the discovery of exploitable reserves, it takes from 8 to 12 years to bring new oil fields into production. Similarly, there are long lead times from the decision to build a nuclear plant or to exploit coal reserves and the actual production of energy on a significant scale.

With hindsight, it is safe to say that earlier projections overestimated the supply response, at least in terms of its timing. It now appears that the lags on the supply side are very long. In developing the constant 1972 oil price projections for the supply of energy two approaches have been taken. The first approach assumes that the supply response is negligible by 1985, and the projections of energy supply in this case correspond to those which take into account the oil price increases. The second approach assumes a small positive price response for those countries with significant indigenous supply. Projections are derived by reducing the first set of estimates based on what is known about supply elasticities and increases in the real price of oil. The first set of projections, assuming a negligible price elasticity of supply, is interpreted as an upper-bound estimate of energy supply in the absence of the oil price increases, while the second set of projections might be considered a lower-bound estimate. In other words, projections of energy supply which take into account the most recent price increases, should be larger than, or, in the most pessimistic case, equal to projections of energy supply based on no increase in real energy prices.

In summary, projections of the demand for energy in the absence of the oil price shocks will be made based on assumptions regarding the growth of real GDP through 1985 and the elasticity of energy demand with respect to real GDP growth. For the supply of energy, two sets of projections are proposed. The first set assumes that supply through 1985 is inelastic with respect to the increase in energy prices; the second set assumes a small positive price response.

Before presenting the actual elasticities and growth rates assumed for the constant real energy price demand projections, it is useful to discuss the assumptions implicit in these calculations. The demand projections imply that oil exporters would have been willing to supply oil at the rate demanded without an increase in the real price of oil. There is little doubt that underlying market forces would have eventually led to an increase in the real price of oil. The assumption is, therefore, meant merely to serve as an analytical device.

The rates of growth of GDP used to project energy demand in the constant 1972 real oil price projections are the same as those used in the projections that take into account the oil price increases. The assumption implicit here is that the long-run growth paths of GDP in the industrial countries have not been affected by the oil price increases. This assumption is a point of controversy in the literature,[9] but there is little hard evidence to support any lasting impact of the oil price increases on potential output. In those studies that have found an impact of higher oil prices on potential output, the effect is small, in the order of one-tenth of one per cent for the United States. This view does not deny that the magnitude of the oil price increases may have complicated demand-management policies resulting in lower growth over the adjustment period, but it postulates that the lower growth performance is not due to the oil price increases per se.

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[9] For a discussion of these issues with reference to the United States see the November/December 1980 issue of Challenge. An article by Dennison supports the no effect view, and, in an interview, Jorgensen supports the opposing view.

Table 3 presents the growth assumptions and the elasticities of the demand for energy with respect to growth in real GDP upon which the constant 1972 real oil price demand projections are based. The elasticities have been taken from empirical estimates based on time series regressions[10] and differ from those shown in Table 1 in that they are adjusted for price changes. Consequently, for most countries they are lower than the unadjusted elasticities calculated during a period of falling prices. The cumulative growth in real energy demand from 1973 through 1985, based on the GDP growth rates and elasticities assumed are shown in the last column of Table 3.

Projections of energy balances to 1985 taking into account oil price increases are mainly based on the projections in the IEA 1980 Review, except for France for which WAES (1977) projections were used.[11] The growth assumptions underlying

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[10] Estimates of income or GDP elasticities based on cross-section estimation for the industrial countries are around one (see, for example, CIA (1979), Nordhaus (1980) and Mittelstadt and Hall (1981)), but this elasticity represents the mean of the activity response of industrial countries. Since this exercise is concerned with the differential impact of higher oil prices on industrial countries, elasticities estimated from time series regressions are more appropriate. Table 3 shows that for some countries the deviations of these elasticities from unity are substantial.

[11] The projection used from this study is that which corresponded most closely to the growth and price assumptions used here, specifically they are from Scenario B in WAES (1977).

TABLE 3

GROWTH RATES OF REAL GDP AND DEMAND ELASTICITIES IN INDUSTRIAL COUNTRIES: 1972 REAL PRICE OF OIL ENERGY DEMAND PROJECTIONS

	Average annual rates of growth in real GDP for the period indicated in per cent (1)				Elasticity of energy demand with respect to real GDP growth (adjusted for relative price changes)(2)	Cumulative growth in real energy demand: 1973–1985 (in per cent)
	1960–1973	1973	1973–1979	1979–1985		
Canada	5.6	7.5	3.2	2.4	.89	34
U.S.	4.0	5.8	2.4	2.8	1.02	37
Japan	10.0	10.0	4.1	5.8	.96	75
France	5.2	5.2	3.2	2.2 (3)	1.16	55
Germany	4.5	4.9	2.3	3.1	1.08	41
Italy	5.3	6.9	2.6	3.5	1.41	66
U.K.	3.2	7.1	1.0	2.2	.57	12

(1) Source: Energy Policies and Programmes of IEA Countries, 1980, unless otherwise noted.

(2) Source: Mittelstadt, A. and Hall, V. "Price and Income Elasticities of Final Energy Demand in OECD Countries." OECD: Unpublished mimeo, 1981, p. 19.

(3) Source: WAES (1977).

these projections are the same as those used for the constant real oil price projections, but the elasticities of energy demand with respect to real GDP growth, unadjusted for price increases, are much lower than those shown in Table 1 for the historical period. Table 4a shows the growth and elasticity assumptions underlying the projections based on the 1981 price of oil. The last column of the table shows the cumulative growth in the demand for energy based on these assumptions. These projections are also based on the assumption of a fixed OPEC supply. For 1985 the level of OPEC production is assumed

TABLE 4a

GROWTH RATES OF REAL GDP AND DEMAND ELASTICITIES IN INDUSTRIAL COUNTRIES: 1981 REAL PRICE OF OIL ENERGY DEMAND PROJECTIONS

	Average annual rates of growth in real GDP for the period indicated in per cent (1)				Elasticity of energy demand with respect to real GDP growth (2)		Cumulative growth in real energy demand: 1973-1985 (in per cent)
	1960–1973	1973	1973–1979	1979–1985	1973-1979	1979-1985	
Canada	5.6	7.5	3.2	2.4	.67	.87	29
U.S.	4.0	5.8	2.4	2.8	.32	.32 (4)	8 (4)
Japan	10.0	10.0	4.1	5.8	.32	.89 (4)	30 (4)
France	5.2	5.2	3.2	2.2 (3)	.39 (3)	.39	15 (3)
Germany	4.5	4.9	2.3	3.1	.52	.26 (4)	8
Italy	5.3	6.9	2.6	3.5	.41	.87	27
U.K.	3.2	7.1	1.0	2.2	−.24	.22	2

(1) Source: Energy Policies and Programmes of IEA Countries, 1980, unless otherwise noted.

(2) These elasticities are implicit in the projections and are unadjusted for price changes.

(3) WAES (1977). For France elasticity is for the 1972-79 period and cumulative growth in energy demand is for the 1972-85 period.

(4) Estimates for the United States, Japan, and Germany have been adjusted to take into account the large fall in oil consumption from 1979 to 1980. Except for the United Kingdom, oil consumption in the other major industrial countries was about the same as in 1979.

to be 30 mbd, or 5 per cent less than the 1979 level, thus a supply constraint is implicit in these demand projections.

The projections of indigenous supply for the zero price elasticity case are taken from the IEA 1980 Review and are shown below in column (4) of Table 5. Alternative supply projections based on a small positive price response are developed here for Canada, the United Kingdom and the United States -- the three largest energy producers among the major industrial countries.

The supply response to higher oil prices is difficult to measure because the link between higher oil prices and net producer prices of energy is tenuous. In the past, government tax policies and price controls have diminished the real return to energy producers, and may have actually inhibited the supply response. Nevertheless, it is conceivable that by 1985 the supply of energy would have been less in the absence of the oil price increases that have taken place.

The alternative supply projections are based on implicit supply elasticities with respect to the real price of oil. The supply elasticities are derived from simulations or forecasts in which the real price of oil is varied and the supply response measured.[12] These elasticities are applied to the per cent change in the real price of domestically produced oil with a lag of about 12 years. For the United States and Canada, owing to the delay in the decontrol of oil prices and uncertainties regarding government policies, it is assumed that only one half of the expected response to the 1973-74 oil price increases materializes by 1985. The projections of energy supply are calculated by starting with the supply projections based on 1981 oil prices and reducing them based on the change in the real price of domestically produced oil and the implicit supply elasticities. These estimates are shown in Table 4b for the three countries considered. The oil price increases are divided into two discrete periods, 1972 to 1974 and 1974 to 1980, since after the first oil price increases there was little change in the real price of oil until 1979-1980. These projections should be considered as a lower-bound estimate since they are based on the real price of oil on a gross basis rather than on a net basis, which would exclude costs of production and government taxes.

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[12] Two sources were used to derive the implicit supply elasticities, OECD (1974) and WAES (1977). For the United States, results are consistent with the supply elasticities used in the Department of Energy model.

TABLE 4b

PROJECTIONS OF ALTERNATIVE SUPPLY OF ENERGY
(based on small positive price elasticity)

	Per cent change real price of domestic oil	Elasticity	Per cent change supply of energy
United States			
1972-1974	76	.1	7.6
1974-1980	100	.1	10.0
Total decrease in supply of energy			17.6
Alternative estimate of energy supply			1280 MTOE
United Kingdom			
1972-1974	272	.05	13.6
1974-1980	19	.025	.5
Total decrease in supply of energy			14.1
Alternative estimate of energy supply			208 MTOE
Canada			
1972-1974	52	.15	7.8
1974-1980	54	.15	8.1
Total decrease in supply of energy			15.9
Alternative estimate of energy supply			234 MTOE

In Table 5 demand projections based on 1972 oil prices and those based on oil price changes through the third quarter of 1981 are combined with supply projections based on price-inelastic supply to derive energy balances in volume terms (column 5). The volume balances are then converted to U.S. dollars using the dollar price per ton of oil measured in 1985 prices. The assumption here is that the prices of imported gas and coal, measured in comparable units, will be about the same as oil prices by 1985. This is a more reasonable assumption for gas than for coal, but given the small share of coal in projected energy imports for 1985 (less than 9 per cent) the upward bias in nominal values will have little, if any, effect on the results. The energy balances shown in the lower half of the table seem large but this is partly due to valuing the balances in 1985 prices. For example, the United States balance of $120,017 million corresponds to a volume of net energy imports that is about 7 per cent higher than net energy imports in 1979.

The differences between the energy balances based on 1981 oil prices and those based on the 1972 price of oil represent the change in energy balances due to the oil price increase. These calculations are shown in Table 6, columns (1), (2) and (3). The sum of column (3), the change in industrial country energy balances, represents the export earnings of the oil-exporting countries due to energy exports to the industrial countries. By 1985, it is assumed that the current account surplus of oil-exporting countries will have fallen to near balance. After the 1973-74 oil price increases, the current account balances of oil-exporting countries fell to $3.3 billion by 1978. While there were reasons to believe that absorption would be less rapid this time around, recent developments in the oil markets, in particular weakness in oil

TABLE 5

PROJECTIONS OF UNADJUSTED ENERGY BALANCES TO 1985 BASED ON ZERO PRICE ELASTICITY OF SUPPLY
(total primary energy in millions of tons of oil equivalent)

A. Projections Based on Constant 1972 Oil Prices

	1973	Per cent change real energy demand 1973-1985 (1972 oil prices)	1985	Energy production 1985 (zero price elasticity)	Excess energy demand (-) 1985	Excess energy demand: 1972 oil prices in 1985 (1) (in U.S.$ millions)
	(1)	(2)	(3)	(4)	(5)=(4)-(3)	(6)
Canada	194.3	34	260.4	278.2	17.8	837
United States	1792.5	37	2455.7	1566.0	-889.7	-41852
Japan	342.0	75	598.5	86.6	-511.9	-24080
France (3)	164.0	55	254.2	86.9	-167.3	- 7870
Germany	265.8	41	374.8	138.0	-236.8	-11139
Italy	132.6	66	220.1	23.3	-196.8	- 9258
United Kingdom	224.0	12	250.9	242.0	- 8.9	- 419

B. Projections Based on 1981 Oil Prices

	1973	Per cent change real energy demand 1973-1982 (1981 oil prices)	1985	Energy production 1985 (zero price elasticity)	Excess energy demand (-) 1985	Excess energy demand: 1981 oil prices in 1985 (2) (in U.S.$ millions)
	(1)	(2)	(3)	(4)	(5)=(4)-(3)	(6)
Canada	194.3	29	250.8	278.2	27.4	8943
United States	1792.5	8	1933.7	1566.0	-367.7	-120017
Japan	342.0	30	444.0	86.6	-357.5	-116688
France (3)	164.0	15	188.0	86.9	-101.1	- 32999
Germany	265.8	8	287.0	138.0	-149.0	- 48634
Italy	132.6	27	169.0	23.3	-145.7	- 47556
United Kingdom	224.0	2	227.5	242.0	14.5	4733

(1) The 1972 price of oil measured in 1985 prices is $6.40 per barrel and is defined as the 1972 price of oil, $2.29 per barrel, adjusted to 1985 using the inflation rate as measured by the average GNP deflator in industrial countries. Converted to dollars per ton the price is $47.04.

(2) The 1981 price of oil measured in 1985 prices is $44.41 and is defined as the 1981 price of oil per ton adjusted to 1985, using the inflation rate as measured by the average GNP deflator in industrial countries. Converted to dollars per ton it is $326.40.

(3) Base year of projections for France is 1972.

TABLE 6

PROJECTIONS OF ADJUSTED ENERGY BALANCES IN 1985 AND ESTIMATES OF REAL EXCHANGE RATE CHANGES BASED ON INELASTIC SUPPLY

	Millions of U.S. dollars					
	Excess energy demand(-) by 1985 assuming:		Change in energy balances due to oil price increase (unadjusted)	Offset due to exports to oil-exporting countries	Change in trade balances due to oil price increase (adjusted)	Change in real exchange rate that would eliminate adjusted change in trade balances by 1985 (1) (in per cent)
	1981 oil price	1972 oil price				
	(1)	(2)	(3)=(1)-(2)	(4)	(5)=(3)+(4)	(6)
Canada	8943	837	8106	6493 (.0222) (2)	14599	13.8
United States	-120017	- 41852	- 78165	67186 (.2297)	-10979	0.0
Japan	-116688	- 24080	- 92608	47589 (.1627)	-45019	-15.1
France	- 32999	- 7870	- 25129	29834 (.1020)	4705	4.0
Germany	- 48634	- 11139	- 37495	36825 (.1259)	- 670	3.3
Italy	- 47556	- 9258	- 38298	24101 (.0824)	-14197	- 5.5
United Kingdom	4733	- 419	5152	36883 (.1261)	42035	35.5
Other industrial	- 43966	- 9910	- 34056	43582 (.1490)	9526	
Total	-396184	-103691	-292493	292493	0	

(1) Derived from the Multilateral Exchange Rate Model and measured vis-à-vis the U.S. dollar.
(2) Share of country's exports in imports of oil-exporting countries from industrial countries based on 1972 trade flows.

prices and the substantial decline in the oil exports of the high price suppliers, suggest that the decline will be more rapid than originally thought. The assumption made here is that the export earnings of the oil exporters shown in column (3) will be spent on imports from the industrial countries. These imports are allocated to the industrial countries based on the share of each country's exports to the oil-exporting countries in the total imports of this group from industrial countries. The shares are based on trade patterns in 1972, shown in parentheses next to column (4), prior to any relative price changes that may have resulted from the oil price increases. In other words, the surplus of the oil-exporting countries is distributed to the industrial countries based on the pattern of trade in 1972. The distribution to each country represents the amount that would have been exported to the oil-exporting countries at unchanged relative prices.

What remains after distribution of the surplus of the oil-exporting countries is the estimated change in the trade balance of industrial countries due to higher oil prices (shown in column 5). The MERM is used to solve for the changes in real exchange rates among the industrial countries that would offset these trade balance changes, other things being equal. These solutions are shown in column (6). Tables 7 and 8 detail similar calculations for the alternative supply projections.

The final estimates of changes in trade balances due to the oil price increases since 1972, shown in column (5) of Table 6, purport to measure the effects of higher oil prices on trade balances other things remaining the same. In particular, industrial countries' competitive positions vis-à-vis each other are held constant. Pressure on real exchange rates arises from two sources in this exercise. First, if it is assumed that countries were initially in equilibrium, the oil price increases disturb that equilibrium by the amount measured in column (3), the impact on energy balances. Second, at unchanged relative prices, the pressure on real exchange rates from the impact on energy balances is either reinforced or offset by countries' expected exports to oil-exporting countries. For example, the United Kingdom experiences upward pressure on its real exchange rate both because of its favourable energy balance and because of its trading position. At unchanged relative prices, the demand for exports from the United Kingdom would be too large. Appreciation of its real exchange rate, vis-à-vis other industrial countries, changes its competitive position in both industrial country markets and in markets in which the United Kingdom competes against other industrial countries for exports, namely, the markets of the oil-exporting countries and the rest of the world.

The changes in real exchange rates shown in column (6) are measured with respect to the U.S. dollar. They indicate the realignment of relative prices among the industrial countries that would enable them to offset the impact of higher oil prices on their trade balances with non-fuel transactions. The results indicate that the United Kingdom would need a relatively large real appreciation to offset the impact of higher oil prices on its trade position. Canada would appreciate to a lesser extent than the United Kingdom against Germany and France mainly because its favourable energy position compared to the latter two countries is offset by their more favourable trading position with the oil-exporting countries. In other words, while Canada is in a much better energy position than France and Germany, it exports much less to the oil-exporting countries than they do. Italy and Japan experience a depreciation of their real exchange rates vis-à-vis the U.S. dollar, Japan's exchange rate depreciating three times as much as Italy's. Both of these countries import the bulk of their energy requirements, but in absolute terms Japan imports nearly three times more energy than Italy, explaining part of the difference in their relative positions. The other part is explained by the fact that Italy's main competitors, the EEC countries, have all appreciated compared with Italy. In the case of Japan, the United States is its most important market and competitor; therefore, a depreciation against the dollar is needed to restore equilibrium. Most countries appreciate against the U.S. dollar. This is explained by the fact that the energy balance of the United States is substantially larger than its expected exports to oil-exporting countries at unchanged relative prices. In other words, except for Japan and Canada, other countries are in a better initial trading position than the United States.

The results based on the alternative energy supply projections shown in Table 8 indicate that the estimates are quite sensitive to energy supply responses. The relative positions of the European countries among themselves remain about the same, but in this alternative they all depreciate compared with the United States. Similarly, Japan depreciates by much more since its energy position relative to the United States worsens significantly. Since the energy supply responses are rather crudely approximated and no attempt has been made to derive similar estimates for Japan and the European countries, estimates based on the alternative supply projections will overestimate the necessary real depreciation of these countries. Similarly, estimates based on inelastic supply will tend to underestimate the strength of those

TABLE 7

PROJECTIONS OF UNADJUSTED ENERGY BALANCES TO 1985 BASED ON SMALL PRICE ELASTICITY OF SUPPLY (total primary energy in millions of tons of oil equivalent)

A. Projections Based on Constant 1972 Oil Prices

	1973	Per cent change real energy demand 1973-1985 (1972 oil prices)	1985	Energy production 1985 (small price elasticity)	Excess energy demand (-) 1985	Excess energy demand 1972 oil prices in 1985 (1) (in U.S.$ millions)
	(1)	(2)	(3)	(4)	(5)=(4)-(3)	(6)
Canada	194.3	34	260.4	234.0	- 26.4	- 1242
United States	1792.5	37	2455.7	1280.0	-1175.7	-55305
Japan	342.0	75	598.5	86.6	- 511.9	-24080
France (3)	164.0	55	254.2	86.9	- 167.3	- 7870
Germany	265.8	41	374.8	138.0	- 236.8	-11139
Italy	132.6	66	220.1	23.3	- 196.8	- 9258
United Kingdom	224.0	12	250.9	208.0	- 42.9	- 2018

B. Projections Based on 1981 Oil Prices

	1973	Per cent change real energy demand 1973-1982 (1981 oil prices)	1985	Energy production 1985 (small price elasticity)	Excess energy demand (-) 1985	Excess energy demand 1981 oil prices in 1985 (2) (in U.S.$ millions)
	(1)	(2)	(3)	(4)	(5)=(4)-(3)	(6)
Canada	194.3	29	250.8	278.2	27.4	8943
United States	1792.5	8	1933.7	1566.0	-367.7	-120017
Japan	342.0	30	444.0	86.6	-357.5	-116688
France (3)	164.0	15	188.0	86.9	-101.1	- 32999
Germany	265.8	8	287.0	138.0	-149.0	- 48634
Italy	132.6	27	169.0	23.3	-145.7	- 47556
United Kingdom	224.0	2	227.5	242.0	14.5	4733

(1) The 1972 price of oil measured in 1985 prices is $6.40 per barrel and is defined as the 1972 price of oil, $2.29 per barrel, adjusted to 1985 using the inflation rate as measured by the average GNP deflator in industrial countries. Converted to dollars per ton the price is $47.04.

(2) The 1981 price of oil measured in 1985 prices is $44.41 and is defined as the 1981 price of oil per ton adjusted to 1985, using the inflation rate as measured by the average GNP deflator in industrial countries. Converted to dollars per ton it is $326.40.

(3) Base year of projections for France is 1972.

TABLE 8

PROJECTIONS OF ADJUSTED ENERGY BALANCES IN 1985 AND ESTIMATES OF REAL EXCHANGE RATE CHANGES BASED ON ELASTIC SUPPLY

	Millions of U.S. dollars					Change in real exchange rate that would eliminate adjusted change in trade balances by 1985 (1) (in per cent)
	Excess energy demand(-) by 1985 assuming: 1981 oil price	Excess energy demand(-) by 1985 assuming: 1972 oil price	Change in energy balances due to oil price increase (unadjusted)	Offset due to exports to oil-exporting countries	Change in trade balances due to oil price increase (adjusted)	
	(1)	(2)	(3)=(1)-(2)	(4)	(5)=(3)+(4)	(6)
Canada	8943	- 1242	10185	6113 (.0222) (2)	16298	13.7
United States	-120017	- 55305	- 64712	63251 (.2297)	- 1461	0.0
Japan	-116688	- 24080	- 92608	44801 (.1627)	-47807	-22.9
France	- 32999	- 7870	- 25129	28087 (.1020)	2958	- 2.9
Germany	- 48634	- 11139	- 37495	34668 (.1259)	- 2827	- 4.5
Italy	- 47556	- 9258	- 38298	22690 (.0824)	-15608	-12.6
United Kingdom	4733	- 2018	6751	34723 (.1261)	41474	30.0
Other industrial	- 43966	- 9910	- 34056	41029 (.1490)	6973	
Total	-396184	-120822	-275362	275362	0	

(1) Derived from the Multilateral Exchange Rate Model and measured vis-à-vis the U.S. dollar.
(2) Share of country's exports in imports of oil-exporting countries from industrial countries based on 1972 trade flows.

countries that may have a relatively stronger energy supply response.

4 CONCLUSIONS

In this paper an attempt has been made to estimate the real exchange rate changes among industrial countries that would offset the differential impact of higher oil prices on countries' balance of payments positions, other things remaining the same. The emphasis has been on the change in countries' competitive positions in the goods market required to offset fuel transactions with non-fuel transactions. There is, no doubt, a large margin of error in these calculations owing to uncertainties regarding developments in energy supply and demand, the validity of the assumptions inherent in the calculations, and the focus on the trade balance. Still, a number of conclusions can be drawn from the analysis.

Among the industrial countries, real exchange rate appreciation vis-à-vis the dollar is likely to be greatest for net energy exporters, the United Kingdom and Canada. Japan and, to a lesser extent, Italy, need a real exchange rate depreciation to offset the impact of higher oil prices, while France and Germany can restore their competitive positions with relatively small changes in their real exchange rates.

Results based on the two energy supply alternatives indicate that the estimates of real exchange rate changes are sensitive to energy supply responses and that the margin of error in these estimates could be reduced by more accurate measurement of the energy supply response. Countries with a relatively greater supply response, other things equal, will tend to experience real appreciation of their currencies, while countries with little scope to expand their domestic supply of energy will either have to depreciate in real terms or reduce energy demand even further.

APPENDIX

Overview of the Multilateral Exchange Rate Model

The systems of equations that make up the Multilateral Exchange Rate Model are illustrated in matrix notation with all variables expressed in percentage change. For a detailed description of the specification of MERM see Artus and McGuirk (1981).

Notation

$\overset{*}{D}{}^k_i$ = per cent change in demand for good i in market k

$\overset{*}{Q}_{ik} = \overset{*}{Q}{}^k_i$ = per cent change in output of good i in country k

$\overset{*}{C}{}^k$ = per cent change in consumption in country k

$\overset{*}{G}{}^k$ = per cent change in government expenditures in country k

$\overset{*}{I}{}^k$ = per cent change in investment expenditures in country k

$$\left.\begin{matrix}[a^k_{in}] \\ [b^k_i] \\ [c^k_i] \\ [d^k_i]\end{matrix}\right\} = \text{fixed input-output coefficients representing the proportion of each good in intermediate and final demand}$$

$[\varepsilon^k_i]$ = income elasticity of demand for good i in market k

$[\bar{\eta}^k_{i/n}]$ = income-compensated price elasticity of demand for good i with respect to good n in market k

$\overset{*}{D}{}^k_{ij}$ = per cent change in the demand for good i produced by country j in market k

$[\bar{\eta}^k_{ij/il}]$ = income-compensated price elasticities of demand for product ij with respect to product il in market k

$[\alpha^k_{i/n}]$ = price elasticity of supply of good i with respect to the price of good n, in volume terms, in market k

$\overset{*}{S}_{ij}$ = per cent change in cost of production of good i by country j

$$\left.\begin{array}{l}[SP^{ij}_{n}]\\ \\ [SP^{ij}_{w}]\\ \\ [SP^{ij}_{R}]\\ \\ [SP^{ij}_{TX}]\end{array}\right\}$$

= fixed input-output coefficients representing the shares in production costs of material inputs and primary factors

SYSTEM OF DEMAND EQUATIONS

I. Demand Equations for Goods

$$(1)\quad \overset{\overset{*}{D}{}_i^k}{\begin{bmatrix}\overset{*}{D}_1\\ \vdots\\ \overset{*}{D}_n\end{bmatrix}} = \overset{a_{in}^k}{\begin{bmatrix} a_{11} & \cdots & a_{1n}\\ & & \\ a_{n1} & \cdots & a_{nn}\end{bmatrix}} \overset{\overset{*}{Q}{}_n^k}{\begin{bmatrix}\overset{*}{Q}_1\\ \vdots\\ \overset{*}{Q}_n\end{bmatrix}} + \overset{b_i^k}{\begin{bmatrix} b_1 & \cdot\;\cdot & 0\\ \vdots & b_2 & \\ & & \ddots\\ 0 & & b_n\end{bmatrix}} \left[\overset{\varepsilon_i^k}{\begin{bmatrix}\varepsilon_1\\ \\ \varepsilon_n\end{bmatrix}} \overset{*}{C}{}^k + \overset{\bar{\eta}_{i/n}^k}{\begin{bmatrix}\eta_{1/1} & \cdots & \eta_{1/n}\\ & & \\ \eta_{n/1} & \cdots & \eta_{n/n}\end{bmatrix}} \overset{\overset{*}{P}{}_n^k}{\begin{bmatrix}\overset{*}{P}_1\\ \vdots\\ \overset{*}{P}_n\end{bmatrix}}\right] + \overset{c_i^k}{\begin{bmatrix}c_1\\ \vdots\\ c_n\end{bmatrix}} \overset{*}{G}{}^k + \overset{d_i^k}{\begin{bmatrix}d_1\\ \vdots\\ d_n\end{bmatrix}} \overset{*}{I}{}^k$$

II. Demand Equations for Products

$$(2)\quad \overset{\overset{*}{D}{}_{ij}^k}{\begin{bmatrix}\overset{*}{D}_{i,\,Aus}\\ \vdots\\ \overset{*}{D}_{i,\,ROW}\end{bmatrix}} = \overset{*}{D}{}_i^k + \overset{\bar{\eta}_{ij/il}^k}{\begin{bmatrix}\bar{\eta}_{i,\,Aus/i,Aus} & \cdots & \eta_{i,Aus/i,ROW}\\ & & \\ \bar{\eta}_{i,\,ROW/i,AUS} & \cdots & \eta_{i,ROW/i,ROW}\end{bmatrix}} \overset{\overset{*}{P}{}_{il}^k}{\begin{bmatrix}\overset{*}{P}_{i,\,Aus}\\ \vdots\\ \overset{*}{P}_{i,ROW}\end{bmatrix}}$$

III. Price Definitions

$\overset{*}{P}{}_n^k =$ price of good n in market k in U.S.$

$\overset{*}{P}{}_{il}^k =$ price of good i produced by country l in market k in U.S.$

$\overset{*}{T}_k =$ exchange rate change vis-à-vis U.S.$

$\overset{*}{PL}{}_n^k = \overset{*}{P}{}_n^k - \overset{*}{T}_k =$ price of good n in market k measured in local currency

SYSTEM OF SUPPLY EQUATIONS

I. Supply Equations for Goods

$$\begin{array}{ccccc} \overset{*}{Q}_{ij} & & \alpha^{k}_{i/n} & \overset{*}{PL}_{ij}-\overset{*}{S}_{ij} & \\ \begin{bmatrix} \overset{*}{Q}_{ij} \\ \vdots \\ \overset{*}{Q}_{nj} \end{bmatrix} & = & \begin{bmatrix} \alpha_{1/1} & \cdots & \alpha_{1/n} \\ & & \\ \alpha_{n/1} & \cdots & \alpha_{n/n} \end{bmatrix} & \begin{bmatrix} \overset{*}{PL}_{ij}-\overset{*}{S}_{ij} \\ \\ \overset{*}{PL}_{nj}-\overset{*}{S}_{nj} \end{bmatrix} & +\overset{*}{T}_{j} \end{array} \tag{3}$$

Definitions

$\overset{*}{W}_j$ = per cent change in wages

$\overset{*}{R}_j$ = per cent change in rental price of capital

$\overset{*}{TX}_j$ = per cent change in net tax payments

II. Cost Indicators

$$\begin{array}{cccccccccccc} \overset{*}{S}_{ij} & & SP^{ij}_{n} & \overset{*}{PL}{}^{j}_{n} & & SP^{ij}_{w} & & & SP^{ij}_{R} & & & SP^{ij}_{TX} \\ \begin{bmatrix} \overset{*}{S}_{i,j} \\ \vdots \\ \overset{*}{S}_{n,j} \end{bmatrix} & = & \begin{bmatrix} SP^{ij}_{1} & \cdots & SP^{ij}_{n} \\ & & \\ SP^{nj}_{1} & \cdots & SP^{nj}_{n} \end{bmatrix} & \begin{bmatrix} \overset{*}{PL}{}^{j}_{1} \\ \vdots \\ \overset{*}{PL}{}^{j}_{n} \end{bmatrix} & + & \begin{bmatrix} SP^{ij}_{w} \\ \vdots \\ SP^{nj}_{R} \end{bmatrix} & \overset{*}{W}_j & + & \begin{bmatrix} SP^{ij}_{R} \\ \vdots \\ SP^{nj}_{R} \end{bmatrix} & \overset{*}{R}_j & + & \begin{bmatrix} SP^{ij}_{TX} \\ \vdots \\ SP^{nj}_{TX} \end{bmatrix} \overset{*}{TX}_j \end{array} \tag{4}$$

Market Equilibrium

(5) $D_{ij} = S_{ij}$

Feedback Effects

(6) $C\overset{*}{O}L_j = \sum_n sc_n^j(\overset{*}{P}L_n^j)$ = per cent change in consumption deflator

(7) $D\overset{*}{D}D_J = \sum_n sg_n^j(\overset{*}{P}L_n^j)$ = per cent change in domestic demand deflator

(8) $D\overset{*}{I}NV_j = \sum_n SI_n^j(\overset{*}{P}L_n^j)$ = per cent change in investment deflator

(9) $\overset{*}{W}_j = w_j \, . \, C\overset{*}{O}L_j$ = per cent change in wages

(10) $\overset{*}{R}_j = r_j \, . \, D\overset{*}{I}NV_j$ = per cent change in return to capital

(11) $\overset{*}{T}X_j = t_j \, . \, D\overset{*}{D}D_j$ = per cent change in indirect taxes

Output Constraint

(12) $\overset{*}{O}_j = \sum_i SH_i(\overset{*}{Q}_{ij} - \overset{*}{P}L_{ij}) = 0$

(13) $\overset{*}{D}A_{j,t} = \overset{*}{D}A_{j,t-1} - (\overset{*}{O}_{j,t} - \bar{O}_j)$

(14) $\overset{*}{C}^j = \overset{*}{G}^j = \overset{*}{I}^j = \overset{*}{D}A_{j,t}$

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REAL AND FINANCIAL INFLUENCES ON THE DOLLAR

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The views expressed in this paper are those of the author and do not necessarily represent those of the Reserve Bank of San Francisco.

1 Since 1973, a major preoccupation of international economists has been the interpretation and prediction of exchange rates. This reflects, in large part, the increasing concern of government officials with the effects of exchange rate variations on the domestic economy, as well as with how (if at all) monetary intervention and other policies should be influenced by exchange market conditions. A significant portion of the effort to understand these issues has been devoted to developing empirical models of exchange rates and their interactions with the domestic economy. These include a growing number and variety of "single-equation" models of exchange rates presented in the literature, as well as the multi-equation models developed at the Board of Governors of the Federal Reserve, the Bank of Canada, and elsewhere.

Anyone seeking to understand, much less model, exchange rates faces a very basic and very old question about their determinants. This concerns the relative influence on exchange rates of _real_ factors -- those determining relative commodity prices in the long run -- versus factors affecting the demands for and supplies of money and other assets. Debate about this question has raged since the formulation of the purchasing-power parity doctrine, but it persists largely unabated to the present day.

One traditional view, as reflected in the writings of Haberler (1936), Yeager (1976) and others has been that exchange rates are affected by a wide variety of factors. These include monetary and financial factors acting through national price levels and interest rates, as well as _real_ factors, those affecting relative commodity prices in the long run. This eclectic view of exchange rate determinants is reflected in the Mundell-Flemming framework widely used during the late 1960s and 1970s and which serves as the basis for many existing empirical models of the exchange rate and the balance of payments.[1] In this framework, exchange rates were viewed as adjusting to equilibrate flows of international payments and receipts. Roughly speaking, then, commercial policies, shifts in tastes or technology, or other real factors acted on exchange rates through the trade and current accounts, while the impact of financial conditions was manifest in the capital accounts. Whatever its other defects, the Mundell-Flemming model was potentially rich with implications for the exchange rate impacts of a wide variety of government policies.

Recent years have witnessed a proliferation of new types of theoretical and empirical models of exchange rate determination. Though the differences among these models have been heavily emphasized and intensely debated, their most distinctive and important feature is one they share in common. This is the view that exchange rates are determined in the short run by conditions of stock equilibrium in asset markets, rather than by flows on current and capital account. These "asset" models have provided considerable insight into exchange rate behaviour, particularly by revealing the critical role that expectations play in exchange rate fluctuations.

Nonetheless, there is growing skepticism that existing formulations of the asset approach provide a comprehensive "blueprint" for future modelling efforts. The main reason is

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1. See Mundell (1960) and Flemming (1962). One notable empirical example is the foreign exchange sector of the Canadian RDX2 model. See Helliwell et al (1969). Gylfason and Helliwell (1981) have developed a theoretical apparatus allowing for real influences on exchange rates in a framework that synthesizes Keynesian, monetary and portfolio approaches.

that while these models undoubtedly provide a more rigorous depiction of how the ultimate determinants of exchange rates influence their short-run behaviour, they have generally been much less eclectic than their predecessors as to those determinants themselves. Most asset models, that is, have attributed exchange rate movements to variations in asset stocks, and the adjustments to them.[2] Because those models have tended to ignore the role of shifts in relative commodity prices, they have actually had less to say than previous approaches about the implications for exchange rates of commercial policies, shifts in competitiveness, or oil price changes. This raises the question as to whether viewing exchange rates as being determined in assets markets in the short run fundamentally alters traditional views of their long-run determinants.

This paper considers what theory and the actual record since 1973 suggest about the relative importance of real and financial factors on exchange rates. Section 2 describes in general terms how real and "monetary" factors (those affecting national price levels) interact to determine exchange rates in the long run, and how variations in interest rates reflect shifts in these long-run determinants and the short-run "adjustments" in exchange rates they induce.

The main concern, however, is with the "lessons" that can be drawn from the actual behaviour of floating exchange rates about their determinants and (thus) about how they should be modelled. The evidence presented in Section 3 strongly suggests, as we will see, that real factors have been a very substantial influence on exchange rates vis-à-vis the dollar since 1973. But there is also evidence, mainly from the behaviour of interest rates, that the relative importance of real versus other factors has changed, particularly since October 1979. Together these (tentative) findings suggest that future models of exchange rates will not only have to allow for a variety of long-run determinants, but also for the possibility that the relative importance of these factors may vary as well.

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[2] This, of course, is not true of all endeavours to implement the asset approach. In particular, several researchers at the Board of Governors of the Federal Reserve have developed exchange rate models explicitly allowing for shifts in relative commodity prices: see Stevens et al (1979), Hooper and Morton (1980), and Isard (1980). However, their approach cannot be said to be typical of asset models as presented in the empirical literature.

2 This section describes what the "modern" theory of exchange rate determination -- which views exchange rates as varying to maintain short-run equilibrium in asset markets -- suggests about their long-run determinants and the characteristics of their short-run dynamics. The main focus is on the implications of the monetary theory of the price level for the impact of real factors on exchange rates in the long run. I then go on to consider the role of interest rates in exchange rates. As we will see, interest rate fluctuations and their covariation with exchange rates are essentially a reflection of shifts in the long-run determinants of exchange rates and of the path exchange rates follow in attaining their long-run values.

2.1 Two Useful Decompositions

Before beginning, it will be useful to define two decompositions of the nominal exchange rate on which the following discussion of exchange rate determinants will be based.

First, at any time t_0, the exchange rate can be viewed as approaching a long-run path determined by the current and prospective future values of its determinants. That is, we can characterize the exchange rate's actual path, as it is anticipated at t_0, as

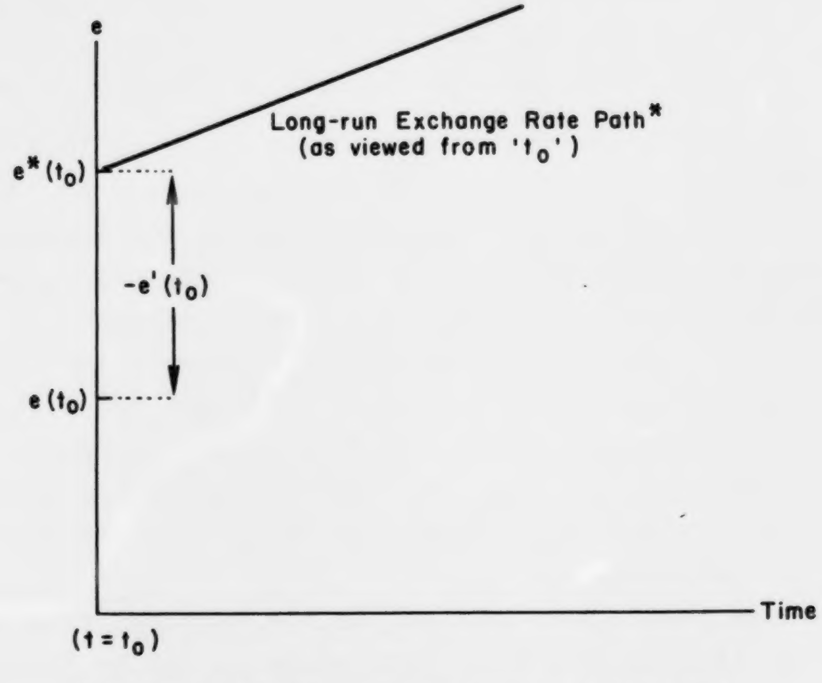
$$e(t) = a(t-t_0) + e^*(t_0) + e'(t) \qquad (1)$$

where e( ) is the logarithm of the dollar value of foreign currency (Figure 1). The long-run path is defined by the first two terms, the first of which, a, gives the long-run average rate of change of e( ), or its "trend", determined by the trends in its determinants. The second component of the long-run path -- its "intercept" $e^*(t_0)$ -- can be thought of as the "long-run" exchange rate since it is the value that would prevail at t_0 were that rate on its long-run path. The remaining element, e'(t), can be thought of as the transient element of e(t) since this element by definition can be expected to disappear over time.

It follows that actual changes in the exchange rate -- on a day-to-day as well as longer term basis -- can be thought of as being composed of three elements: movements along (or parallel to) the current long-run path; shifts in the long-run path itself due to changes in a or e*( ) or both; and movements about the long-run path reflected in variations in the transient element e'( ). Shifts in the long-run path result from new information about the long-run determinants of e( ) and are, in this sense, unanticipated; on the other hand,

Figure 1

LONG-RUN AND TRANSIENT COMPONENTS OF THE NOMINAL EXCHANGE RATE


e
Long-run Exchange Rate Path*
(as viewed from 't_0')
$e^*(t_0)$
$-e'(t_0)$
$e(t_0)$
$(t = t_0)$
Time

*The slope of the long-run path equals 'a', the trend rate of change in the exchange rate

Symbols: $e(t_0)$ - logarithm of the dollar value of foreign currency prevailing at t_0

$e^*(t_0)$ - long-run value of e( ) (its value on the long-run path corresponding to t_0)

$e'(t_0)$ - transient component of e( ) (difference between e( ) and its long-run value) variations in e'( ) are partially predictable because this component is transient. It should be obvious from this characterization that any satisfactory model of exchange rates, however short-term its focus, must account for their long-run determinants.

The main reason for drawing these distinctions is that, as we will see, the relative influence of various exchange rate determinants on its components as defined in equation (1) will generally differ; that is, monetary factors could be found to be the major influence on "a", while different factors could be the primary influence on e* or e'. Furthermore, the relative importance of the components to economic agents (including policymakers) is apt to vary with the types of activities they are engaged in, and particularly their time horizon.[3]

We can also decompose the exchange rate into a "real" component and one reflecting price levels. Let $p(p^f)$ stand for the logarithm of a measure of the U.S. (foreign) price level (i.e., a price index). Then we can write

$$e(t) \equiv y(t) + x(t); \; y(t) \equiv p(t) - p^f(t);$$

$$x(t) \equiv e(t) - y(t) \qquad (2)$$

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[3] Any agent whose return depends upon future realizations of e( ) must reckon with the possibility that "a" as well as e*( ) and e'( ) may change unexpectedly. Over a fairly short horizon, the trend component of exchange rate changes will tend to be relatively smaller compared to fluctuations in e*( ) and e'( ) than over a longer horizon. Agents with long horizons will thus have to be more concerned with factors causing the trend to shift and less concerned with variations in the remaining components, than those with short horizons.

where $y(t)$ is the "purchasing-power-parity" value of the exchange rate. The term x is often referred to as the *real* exchange rate because it is effectively a weighted average of the relative prices of individual commodities expressed in the *same* currency. This can be seen by writing the definitions of the price levels -- $p \equiv \Sigma w_i p_i$ and $p \equiv \Sigma w_i^f p_i^f$, where the weights w_i and w_i^f, sum to one -- and substituting in (2) and rearranging terms:

$$x(t) = \Sigma w_i^f(p_i^f(t) + e(t) - pi(t)) + \Sigma(w_i^f - w_i)(p_i(t) - p(t)) \qquad (3)$$

Thus, $x(\ )$ is essentially an average of the individual dollar prices of foreign relative to corresponding U.S. goods.[4]

Plainly, the path of the PPP and real exchange rates can be characterized in the same way as the nominal exchange rate. The *long-run* real exchange rate x^* is of particular interest here because its variations (by definition) reflect *persistent* shifts in relative commodity prices. The conditions causing such "permanent" changes in relative prices will be referred to as *real factors*.

Obviously, real factors include determinants of factor supplies, productivity, tastes and other factors normally associated with commodity markets and which determine their long-run demands and supplies. However, real factors may also include influences emanating from financial markets to the extent these have persistent effects on relative commodity prices. For example, monetary expansion leading to inflation is often asserted to have real effects -- by raising uncertainty about inflation and so discouraging investment, shifting investors' portfolios towards real capital at the expense of money holdings, or by "distorting" tax incentives so as to favour certain activities while inhibiting others. To the extent that financial policies so alter relative prices, they must be included in the list of real factors. Note, on the other hand, that (for reasons that will become apparent below) real factors do not include strikes or other factors leading to purely temporary changes in relative prices. As we will see, the task of interpreting exchange rate movements is largely that of identifying and interpreting variations in their real components.

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[4] More precisely, variations in the relative dollar prices of foreign to U.S. commodities will change x. However, variations in the relative prices of U.S. goods, U.S.-foreign relative commodity prices held fixed, will also change x *if* the weights in the U.S. and foreign price indices differ. Reasons why these will generally differ (given an appropriate definition of x) are given later in the text.

2.2 Long-Run Exchange Rate Determinants

The first and most basic step in modelling exchange rates is the description of their long-run determinants. Any satisfactory model must account for these determinants, even if its primary focus is on short-run fluctuations in exchange rates.

In the long run, all prices -- commodity prices, interest rates and exchange rates -- must be consistent with equilibrium in all markets. This is particularly true of exchange rates, which affect fairly directly the demands for and supplies of financial assets, commodities and services. For example, the anticipated change in the exchange value of the dollar affects the demand for U.S. versus foreign securities because it is a component of their relative yields; the exchange value of the dollar also influences the demand for U.S. and foreign goods because it is an element of their relative prices. Thus in general, conditions in both commodity and asset markets can be expected to affect equilibrium exchange rates; there is no a priori reason to suppose one set of factors affects exchange rates while the other does not.

In fact, applying the decomposition (2) to the long run,

$$e^*(t) = y^*(t) + x^*(t) \tag{2'}$$

we can see that two sets of factors constitute the exchange rate's long-run value. The first are those determining national price levels. The second are real factors determining the long-run relative prices of individual commodities, whose influence is apt to be reflected in the real exchange rate. However, this decomposition merely serves to classify factors affecting the exchange rate. To go further, we have to analyze how real and price level determinants interact in the long run.

The analysis can be carried beyond mere classification by drawing on the standard monetary theory of the price level. Recall that this is based on the premise that individuals and businesses hold money in large part to carry out their transactions. The nominal amount of transactions a given aggregate money stock M can "finance" is MV, where V, the average rate at which money circulates, depends mainly on the average lag between payments and receipts and on the availability and attractiveness of substitutes for money.[5] On the other hand, the amount of transactions individuals and businesses desire to carry out is PQ, where P is a measure of the average level of prices at which transactions are carried out and Q is the average real level of these transactions; Q depends mainly upon real income and real wealth, which determine the amount of real expenditure agents wish to undertake. Hence the price level is given by

$$P = MV/Q \qquad (3)$$

where Q/V can be thought of as the "real" demand for money.[6]

Most important, this theory also suggests that variations in relative commodity prices (arising from real factors) normally will have little or no impact on the real demand for money, and hence on the price level. Such relative price changes raise the real income and wealth of some agents, but generally at the expense of others so that aggregate real income and wealth are, at least to a first approximation, unaffected. It cannot be overemphasized, though, that this implication applies only to "broad" measures of the average price level that are representative of transactions carried out in the economy as a whole. Almost certainly, such measures will include the prices of non-traded as well as traded goods and services -- an observation we will see has important implications for exchange rate determination.

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[5] Of course, the attractiveness of money substitutes depends, in part, upon interest rates.

[6] In principle, a variety of factors might affect this real demand. These include the stock of government debt to the extent it is viewed as a net addition to wealth by the private sector. Current account balances might also affect the demand for money by changing the home-foreign distribution of wealth. Indeed, it is precisely these variables that receive great emphasis in generalized "portfolio", as opposed to monetary, models of exchange rates (see Kouri (1976) or Branson et al (1977)). However, the evidence, at least for industrial nations, suggests that this impact upon the price level in the long run is quite small.

In any case, the consequences of this view can be seen by imagining that the decomposition (2') and definition of the real exchange rate, (3), have been carried out using "broad" measures of the price level conforming to the above theory. Suppose some real factor leads to a change in the real exchange rate by altering relative commodity prices. Because the level of prices in either country, and hence the PPP component, is unaffected, the nominal exchange rate must change by the same amount as the real component. In effect, the money stock, by constraining the average level of prices, forces the nominal exchange rate to adjust to a change in relative prices. The variety and significance of the real influences on exchange rates implied by the monetary theory of price levels can be seen from the following examples.

Consider first a country that experiences an increase in the demand for its traded goods that raises their prices relative to those of foreign-produced commodities; to simplify matters, suppose the relative price of domestically produced traded versus non-traded goods is not significantly affected. One way in which the required change in relative prices could occur would be for the domestic price of home-traded goods to rise, or the foreign currency prices of foreign goods to fall, with no change in the exchange rate. But this would imply a rise in the domestic price level or a fall in the foreign price level, which is ruled out so long as money stocks are fixed. Clearly, the nominal exchange rate must rise if the required change in relative prices is to occur with no change in average price levels.

Nothing in this reasoning implies that real influences on exchange rates are confined to those affecting the prices of traded goods. To see this consider a country, such as Hong Kong, which is virtually a "price-taker" in international trade with little or no influence on the relative prices of its traded goods. (I ignore its banking sector, which most likely is not a "price-taker" for its exported services.) Suppose the government were to reallocate a significant portion of the colony's land away from housing and towards the export sector, inducing a rise in the price of non-tradeables (housing) relative to tradeables. The same reasoning as before indicates that this change cannot occur through a rise in the price of housing services alone. Plainly, the price of traded goods must also fall if the price level is to remain fixed. But given the relative prices prevailing among traded goods, this can occur only if the exchange rate appreciates.

It should now be clear that the impact of a given relative price change on the nominal exchange rate depends mainly upon the structure of the monetary constraint on the price level, and not on whether the price change occurs in the traded or non-traded goods sectors. As can be seen from relation (3), the impact on e of a given relative price change depends on the importance in transactions of the corresponding goods, which determines the weight they receive in the home and foreign price indices. Thus, it is quite conceivable that real influences on the exchange rate emanating from non-traded goods sectors may outweigh those originating in the tradeables industries.[7]

These arguments apply most directly to countries that either allow their exchange rates to "float", or those that target the domestic money stock and periodically adjust the actual exchange rate to conform to its long-run equilibrium value. However, they are no less relevant to those that peg their exchange rates. In this case, with the exchange rate fixed, it is the domestic price level that must adjust to variations in the real exchange rate. In the first illustration given above, for example, if the exchange rate were not allowed to adjust, the country would experience current account and balance of payments surpluses. These would continue until the domestic money stock had grown enough to allow the price level increase required to "validate" the rise in the relative prices of its traded goods. The outcome would be the same in the second case (with the increase in tradeable goods supply generating the balance of payments surplus). Thus, if real factors can influence exchange rates under a floating rate regime, it is equally true that they can influence the price level, albeit indirectly, when exchange rates are fixed.[8]

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7. Humphrey (1981) provides a similar analysis of why variations in the prices of non-traded goods (the "internal price structure") can affect exchange rates: see pp. 6-7.

8. Thus, if real influences on the long-run exchange rate are important, they can lead to significant variability in price levels under fixed exchange rates. And, as Darby (1980) has pointed out, a predetermined path for domestic money growth will generally not be consistent with a fixed exchange rate (or a preassigned path) for it. The implications for "crawling peg" regimes should be obvious.

2.3 Is the Current Account a Proxy for the Real Rate?

The above arguments suggest that even the task of modelling the long-run exchange rate is a potentially complex one. Not only must national price levels be "explained" but a possibly large number of relative prices -- among traded goods and between traded and non-traded goods -- composing the real exchange rate must in principle be accounted for.

In part to avoid the difficulty, a number of analysts (Isard (1980), and Hooper and Morton (1980)) have proposed using shifts in the current account as a proxy for variations in the long-run real exchange rate. Other analysts have assigned a prominent role to current accounts in explaining actual movements in exchange rates since 1973 (e.g., Dornbusch (1980)). The basic rationale is that in the long run, the real exchange rate must be consistent with the equilibrium level of a nation's current account balance.

While this is certainly the case, it is clearly an oversimplification to suppose there is a fixed, unambiguous relation between the real exchange rate and the current account balance. The real exchange rate, which is an average of several relative prices, must be compatible with equilibrium in all markets, not simply current account equilibrium.[9] To see the difficulties that can arise with this proxy, recall from the first illustration given earlier that a rise in demand for a nation's traded goods raises the real exchange rate while (initially) improving its current account balance. Suppose, though, that an increase in productivity raised the home supply of traded goods with no change in demand: the current account balance would again improve but the real exchange rate (i.e., the terms of trade) would fall.

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[9] Additional problems arise when the long-run equilibrium level of the current account shifts because of alterations in domestic savings and investment propensities.

More generally, the link between the current account and the real exchange rate is not a behavioural relation depending mainly upon commodity demand and supply elasticities. Rather it is a reflection of the relative magnitudes and frequencies of the disturbances causing shifts in the exchange rate. The relation between the current account and the real rate can thus be expected to vary across countries and over time. While this does not necessarily mean that the current account cannot be a useful proxy for movements in the real exchange rate in actual practice, it does suggest that such a proxy may be of limited use in models designed to explain and predict exchange rate movements over an extended period of time.[10]

2.4 Adjustment to the Long Run

If exchange rates immediately attained their long-run values, their short-run movements could be modelled in essentially the same way as their long-run behaviour. But nearly all models depict the observed exchange rate as moving continuously about its long-run path. Theorists, in accounting for such movements, have tended to focus on protracted adjustments in the exchange rate and its components towards their long-run values caused by "rigidities" in various markets.[11] Conventional wisdom more often attributes short-term exchange rate variations to fluctuations in interest rates. Considerable effort in recent years has gone into modelling the factors explaining the "short-run" dynamics of exchange rates, and into reconciling these two views.

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[10] As we will see, a major difficulty with using such proxies arises if they "miss" a significant portion of actual variations in $x^*(\ )$; in that case, observed variations in $x(\ )$ may easily be attributed to real interest rate variations.

No less than other approaches, asset models suggest that exchange rates may take considerable time to adjust to a change in their long-run determinants. These adjustments reflect the fact that certain determinants of asset supplies and demands -- such as commodity prices and wealth levels and asset stocks -- generally require some time to change, preventing the immediate attainment of long-run equilibrium in these markets.[12] But these models have gone considerably beyond earlier approaches in clarifying the mechanisms and factors determining short-run exchange rate dynamics.

The asset approach has proven particularly useful in characterizing the relations among exchange rate and interest rate variations. In fact, it demonstrates clearly that, at least among countries where capital is highly mobile, interest rate variations in a sense reflect the pattern of shifts in the long-run real and PPP components of exchange rates, as well as characterize the short-term adjustments to the long run that these shifts induce.

To see this, assume that comparable U.S. and foreign assets are perfect substitutes in the sense that their covered and uncovered (ex ante) yields are the same; thus, the U.S.-foreign interest differential equals the forward premium on the exchange rate, while the forward rate equals the spot value anticipated to prevail at maturity.[13] Now consider a long-term asset with a duration of "N" periods, where N is sufficiently great to ensure that the current exchange rate e(t) has adjusted to its long-run value, $e^*(t + N)$, by maturity. Defining the foreign-U.S. differential, in(t), on this asset as the difference in the cumulative percentage yield earned over the holding period, we can write

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[11] A prime example is Dornbusch (1976).

[12] See Whitman (1975).

$$in(t) = e(t) - e^*(t + N) \qquad (4)$$

Now the long-run or unconditional mean of the interest differential must, by the same argument, equal the long-run average change in the exchange rate over N periods, which is simply the "distance" along the long-run path over N periods as indicated by Figure 2. It follows immediately that the difference between the actual long-term interest differential and its long-run value is equal to the departure of the exchange rate from its long-run path, or

$$in'(t) \equiv in(t) - in^*(t) = e(t) - e^*(t) = e'(t) \qquad (4')$$

Thus, shifts in the long-run mean of the interest differential correspond to shifts in the trend rate of change in the

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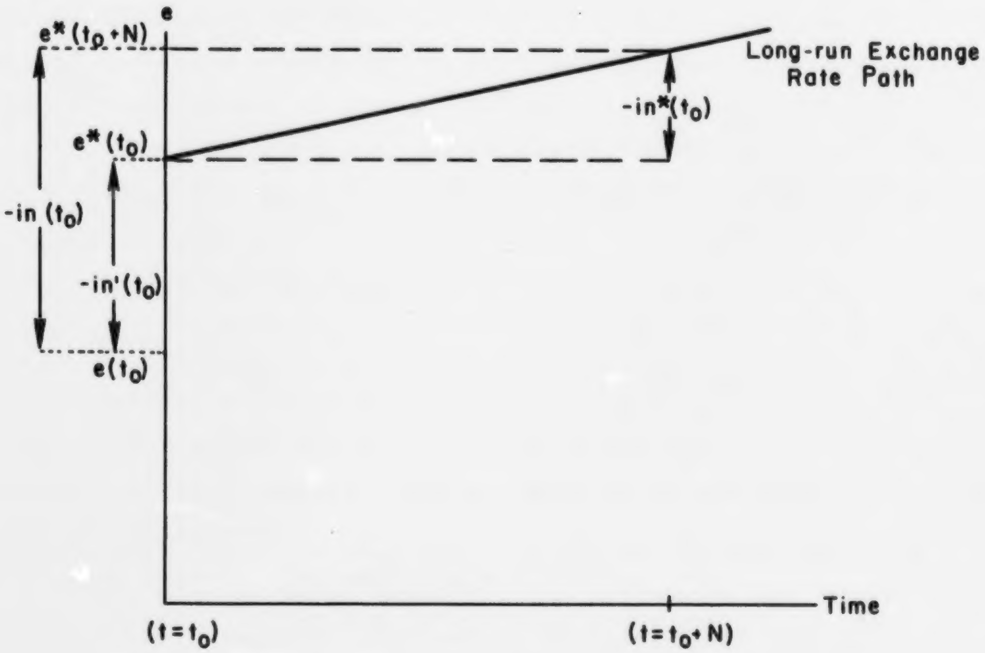
[13] There is considerable evidence that covered interest parity holds nearly exactly in the eurocurrency markets, at least up to a year's maturity. While there is also evidence of a risk "premium" in the forward market, there are also indications from several empirical "asset" models that its variations are not very large, at least compared to exchange rate variations themselves (see Isard, 1980). Thus, I feel fairly confident in using "perfect" capital mobility as a reasonable approximation of the pattern of interest-exchange rate variations observed for industrial countries.

Figure 2

THE CORRESPONDENCE BETWEEN
NOMINAL INTEREST RATES AND EXCHANGE RATES


e
e* (t0+N)
e* (t0)
-in (t0)
-in' (t0)
e(t0)
Long-run Exchange Rate Path
-in*(t0)
Time
(t=t0)
(t=t0+N)

Symbols: $in(t_0)$ - N period long-run foreign-U.S. interest differential (nominal) at t_0

$in^*(t_0)$ - long-run value of in( ) expected as of t_0

$in'(t_0)$ - deviation of in( ) from its long-run value, in^*

$e^*(t_0+N)$ - long-run path value of exchange rate expected to prevail at t_0+N, as of t_0

exchange rate; variations in in( ) about its mean correspond to (perceived) variations in e( ) about its long-run path.

Finally, as is well known, we can decompose the nominal interest rate into a premium for anticipated inflation and a real component, measuring the yield in (domestic) commodities. Let $\pi(t)$ stand for the expected foreign-U.S. inflation differential over N periods and ir(t) for the corresponding N-period real interest differential. Then, using (3) and (4), we can write

$$\pi(t) = y(t) - y^*(t + N) \tag{5a}$$

$$ir(t) = x(t) - x^*(t + N) \tag{5b}$$

And by applying the same reasoning as above, we can see that changes in the average inflation or real interest differential signify shifts in the trend of the PPP and real exchange rates, while deviations in $\pi(\ )$ and ir( ) from their averages measure the transient components of y( ) and x( ).

2.5 Adjustment Patterns and Interest Rates

From the above, it is obvious that we could learn a great deal about the behaviour of exchange rates simply from observing the fluctuations in nominal interest rates and their real and nominal components. For example, the variability of the long-run nominal and real interest differential provides one measure (an incomplete one) of the relative influence of real factors on the long-run path of exchange rates.[14]

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[14] That is, the greater the variability of long-run real interest differentials compared to change in inflation premiums, the greater the relative influence of real factors on the nominal exchange rate's trend.

Furthermore, the observed variability of interest rates about their long-run average provides an indication of the extent to which adjustments to the long run, versus shifts in long-run values, account for observed exchange rate changes. And more generally, alternative models of exchange rate dynamics can be characterized by the pattern of interest rate variations they imply.

To illustrate, consider the simple monetary model of the exchange rate that assumes that "purchasing-power parity" holds continuously, so that the real exchange rate is essentially fixed. This model then allows only for variations in the PPP component of the exchange rate, and in the inflation premium component of interest rates. Since a rise in foreign minus U.S. inflation implies an eventual fall in the dollar value of foreign currency, these models imply that, typically, an increase in the interest rate differential in favour of the home country will lead to an immediate fall in the forward exchange rate followed by a depreciation of the spot rate. Furthermore, because higher expected (differential) inflation implies a bigger "gap" between the spot exchange rate and its anticipated future value, this model also implies that the variability of the forward rate will exceed that of the spot rate.[15]

As Dornbusch (1976) has graphically demonstrated, the implications of this simple monetary model are at variance with those of many empirical models of interest rate determination, particularly those embedded in the large econometric models. These are based upon the "slow" adjustment of prices to increases in money stocks. Because of this, a rise in money initially raises real money balances, which normally leads to a fall in the real, and often the nominal, interest rate as well as a rise in the inflation premium. Since the increase in money does not affect the long-run real exchange rate (and because prices do not respond immediately), both the nominal and the real exchange rates initially decline, with the real rate (at least) rising back with the real interest rate towards its initial value as prices respond. Thus, in contrast to the monetary model, the Dornbusch framework suggests that in the short run, increases in the interest differential will be associated with (contemporaneous) increases in the nominal and real exchange rates.[16]

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[15] See Brittain (1977).

Dornbusch's model provides one possible explanation for the widely believed tendency of nominal exchange rates to "anticipate" changes in the long-run PPP, by moving "ahead" of current price levels. Because of this, and because his depiction of the adjustment process is so compatible with widely held theories of interest rates, it has been highly influential. More generally, this model, as well as most other asset approaches, implies that the rough dichotomy prevailing in the long run between factors affecting PPP and those influencing the real exchange rate breaks down during the "adjustment process". That is, because of price rigidities, shifts in long-run PPP produce short-term variations in the real exchange rate; generally, also in these models, real factors affecting x* can lead to short-term variations in price levels, and hence the PPP component, as well as in the real exchange rate.[17]

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[16] The most controversial feature of this model is its prediction that a rise in the U.S. money stock will lead to a more than proportionate fall in the dollar. This "overshooting" property results because, in this model, the nominal interest rate initially declines, pushing the spot rate below its expected future (forward) value. As Dornbusch notes, this implication is much less robust than the more basic conclusion about the real interest and exchange rate responses to money.

The interpretation of actual exchange rate variations is naturally complicated by the breakdown of this long-run "dichotomy" in the short run. Real exchange rate variations are composed of changes in their long-run expected values and temporary fluctuations about the long run reflected in real interest variations about their mean. Unfortunately, neither the long-run real exchange rate nor real interest rates are directly observable. If we cannot adequately model changes in x*, we are apt therefore, to give a misleading indication of the importance of real interest rates in accounting for actual variations in real and nominal exchange rates.[18] However, while lack of direct information about real interest rates is an obstacle to determining the importance of real factors, it need not be an insurmountable obstacle. Real factors (by definition) lead to persistent shifts in the real exchange rate, which suggests that the tendency of observed changes in x to persist in the long run provides a measure of their importance (more on this in the next section).

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[17] Consider, for example, a situation in which individuals reduce saving to purchase more housing services, with no change in spending on other goods and services. Then we might observe the following adjustment pattern: housing prices rise leading to a temporary rise in the price level and fall in real money balances; as a result, real interest rates rise, raising the real exchange rate towards its long-run value; as higher real interest rates lower spending on other goods, their prices fall, bringing the price level and real interest rates back to their original values. This is purely hypothetical, of course. On the whole, very little attention has been given in the literature to the dynamics of exchange rate ajustments to real factors.

[18] To take an extreme case, if we regard the long-run real exchange rate as fixed, we must attribute observed variations in x( ) as reflecting fluctuations in real interest rates. In fact, we could use changes in the real exchange rate to measure changes in the long-term real differential in this case, as Isard (1980) has done.

2.6 How Important Are Adjustments?

The Dornbusch model illustrates that a useful way to think about the process of exchange rate adjustment is to consider what monetary and finance theories imply about the interest rate consequences of shifts in the long-run determinants of exchange rates. In particular, there are other theories of interest rates that suggest that movements of exchange rates about their long-run values are apt to be much less important than most asset models -- empirical as well as theoretical -- imply.

Note again that the variability of nominal or real interest differentials (about their long-run average) relative to that of nominal and real exchange rate changes provides a measure of the relative importance of "adjustments" compared to changes in e* and x*. That is, asserting that fluctuations in e about its long-run values account for a large part of its observed movements, is tantamount to asserting that interest rate fluctuations about the mean, since they "measure" these movements, are relatively variable compared with exchange rate changes.

Now, a widely accepted implication of finance theory is the notion that markets for financial and real assets are likely to be reasonably efficient. In such markets -- where information is widely and quickly disseminated and transactions costs are relatively low -- a strategy of buying and simply holding a diversified portfolio of assets should, on average, provide at least as high a return as a "trading" strategy that calls for switching between assets on the basis of past price behaviour or other "old" information. Under certain circumstances, this view implies that changes in nominal and real long-term interest rates should be essentially random. That is, such changes should represent shifts in the unconditional means of nominal and real interest rates which, as we have seen, must correspond to changes in the average or trend rate of change in the nominal and real exchange rates.[19]

In contrast, the Dornbusch and other asset models suggest that variations in money growth will lead to variations in real (and nominal) interest rates about their mean. Such fluctuations must, of course, be serially correlated and hence, are in part predictable. But then, if such variations are very large, that is if the exchange rate adjustments they reflect are empirically important, markets for long-term financial and real assets almost certainly must be substantially inefficient in the above sense. Conversely, viewing stock and bond markets as efficient strongly suggests that exchange rate adjustments to the long run are not very

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19. Consider comparing the real return on bonds with that of stocks and suppose the latter is fixed. If the real return on bonds fluctuated predictably, it would be possible to design a strategy of switching between bonds and stocks, depending on whether bond yields were relatively high or low, that would yield a higher over-all return than simply holding a fixed diversified portfolio of these assets. Such a strategy would not, of course, yield a superior return if the real yield on stocks varied with that of bonds. But predictable fluctuations in real stock yields are inconsistent with the fairly well-established efficiency of the stock market.

important.[20]

While I would not want to push this view too far, it does highlight a potentially limiting aspect of existing asset models. These models generally consider substitutions among a limited spectrum of assets, generally between domestic (or foreign) money and bonds. Given the relatively low interest elasticity of money, it is not entirely surprising that these models "predict" fairly large fluctuations in interest rates. More general finance theories, in contrast, allow for a wider range of substitution possibilities, which may limit these fluctuations. If, as some of the evidence presented in the next section suggests, exchange rate adjustments are not generally a very important component of their over-all movements, these more general models may provide a useful direction for future research.

2.7 Temporary Influences on the Exchange Rate

Plainly, not all variations in the exchange rate about its long-run value need result from adjustments to shifts in its long-run determinants. Temporary changes in price levels could also lead to such fluctuations in e and its PPP component, just as other temporary influences, such as strikes or poor harvests, might change relative commodity prices, and hence the real exchange rate, without altering their long-run values.

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[20] Again in the (fairly strong) sense that a "trading strategy" should, on average, yield no higher return than a "buy-and-hold" strategy. Eugene Fama, Foundations of Finance, 1976, discusses various notions of market efficiency in more detail. (See pp. 133-137.)

The events of the last two years have led to increased interest in the effects of one such temporary influence. This is the variation in real (and nominal) interest rates arising from temporary fluctuations in supply and demand in money and credit markets. These could arise from seasonal shifts in credit demand, unusually heavy borrowing needs by the federal government or private corporations, or other factors. Though such temporary shifts are unlikely to affect either the long-run PPP or real components of the exchange rate significantly, they can, of course, lead to temporary fluctuations in the latter.

The renewed attention to such fluctuations arises in large part from the Federal Reserve's change in operating procedures in October 1979. Under the old procedures, the Fed effectively "smoothed out" short-term nominal and (presumably) real interest fluctuations; under the new procedures, short-term rates have been allowed to fluctuate much more freely. The general presumption has been that the new procedures would thus result in greater short-term variability in real and nominal interest rate differentials and greater variability in spot exchange rates.[21]

The previous analysis shows that the impact of such credit market fluctuations on the exchange rate has two dimensions. Relation (5) implies that if the long-run real exchange rate is fixed, x itself varies in proportion to the change in the long-term real interest differential expressed as the difference in yields over the entire holding period. For example, a rise of 10 basis points in the annualized five-year

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[21] Keran and Pigott (1980) and Truman et al (1981) discuss these issues in more detail.

(real) interest differential will induce an increase in x of (roughly) 50 basis points.[22]

It follows that the exchange rate impact of a given "shock" in credit markets depends on two factors. The first is the size of the change in very short-term real interest rates it produces. The second is the duration or "persistence" of the change, which determines how much longer term rates vary with short-term yields. For example, a disturbance that raises three-month real interest rates by 100 basis points (annualized) but which is expected to disappear after maturity will, by the previous reasoning, increase x by about 25 basis points. However, if the increase is expected to persist for a year, the impact will be four times as great.

This observation has some implications for the modelling of exchange rates. Generally, we cannot expect that the variation in the exchange rate produced by a given change in real interest rates will be stable in time -- unless the maturity is fairly long term. Again, the impact of changes in short-term real interest rates depends upon how great a change they produce in long-term real interest rates. Exchange rate equations including short-term interest rates as explanatory variables are, in effect, using them as proxies for the longer term variations. Because these "term-structure" relations may change over time, such equations are apt to be unstable. More

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22. That is, a 10-basis point rise in the annualized yield implies that the dollar value of foreign currency will rise by 10 basis points per year over the next five years. The "distance" to the long-term forward rate thus must change by 50 basis points. If we assume the real interest rate increase has no impact on the 5-year forward rate, it is evident that the spot dollar value of foreign currency must decline by 50 basis points.

generally, modelling the relation between exchange rates and interest rates is likely to require explicit attention to the term structure.

In any case, knowledge of the extent to which real interest rates actually vary may well prove crucial for the interpretation of observed exchange rate movements. Several recent studies of the U.S. experience (Nelson and Schwert (1977) and Mishkin (1981)) suggest that short-term real interest rates do indeed vary over time. However, it is very doubtful that the variations in short-term real rates implied by these studies are large enough to be the primary source of real exchange rate changes, unless fluctuations in short-term real interest rates are also fairly persistent, and so "carry over" to longer term rates.[23] It is interesting to note that these studies also suggest strongly that the variability of real interest rates has also changed periodically; in particular, real rates seem to have been noticeably more stable during the 1960s than during the 1970s. As we will see in the next section, the pattern of covariation of interest rates and exchange rates strongly suggests that the variability of real

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23. To illustrate, note that Mishkin's estimates suggest that the standard deviation of the 3-month U.S. real Treasury bill rate was about 100 basis points (or less) over the 1973-79 period (see Mishkin (1981) Figure 3 on p. 174). Now suppose, first, that these fluctuations tended to persist for one quarter only; then the standard deviation of the one-year real rate would be 25 basis points. Imagine, also, that foreign real rates are uncorrelated with their U.S. counterparts and equally variable. Then, the standard deviation of the one-year real differential in favour of the United States would be about 35 basis points, which is considerably less than the standard deviation of fluctuations in real exchange rates. Thus, fluctuations in short-term real rates must persist for considerably more than one quarter if they are to account for the sharp variations in real exchange rates actually observed.

interest rates has changed again, increasing sharply since the shift in Federal Reserve operating procedures in October 1979.

3 The previous analysis suggests several questions about the actual behaviour of exchange rates, the answers to which are apt to prove critical in deciding how to model them. Perhaps the most basic is the extent to which real influences, versus factors determining national price levels, can account for observed variations in exchange rates. Another basic issue involves the empirical relation between interest rate and exchange rate changes. As we saw earlier, this pattern provides an indication of the types of adjustments exchange rates undergo in moving towards their long-run values.

This section presents evidence on these questions for the dollar's exchange values vis-à-vis several major foreign currencies. However, the earlier analysis also suggests that the answers to these questions cannot be expected to be the same for all countries, or even for different periods for a given nation. The evidence presented at the end of the section suggests that shifts in the relative importance of factors influencing exchange rates is a very real possibility. In particular, the portion of exchange rate fluctuations accounted for by (probably real) interest rate variations -- more correctly the factors causing them -- appears to have risen substantially since October 1979.[24]

Before proceeding, it should be noted that most of the evidence presented below refers to exchange rate changes relative to their mean or trend rate of change. As explained earlier, we can view exchange rate movements as being composed of three elements: an average or trend rate of change, essentially random shifts in their long-run path (that is, changes in the trend or in the path's level, e*); and transient movements about the long-run path (changes in e'). Again, there is no reason to suppose that the relative importance of real and other factors will be the same for these elements. Indeed, studies of purchasing-power parity strongly suggest that shifts in the exchange rate's average rate of change, across countries and over time, are mainly accounted for by changes in inflation rates, that is, by shifts in the trend in PPP. For this reason, I focus on the other elements of exchange rate movements where the influences are quite different.[25] In so doing, we are in no sense considering a minor aspect of exchange rate movements because, as we will now see, variations in exchange rate changes about their mean have been very large compared to the mean itself.

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[24] The Truman et al (1981) study presents considerable additional evidence supporting this conclusion.

3.1 The Variability of Real Exchange Rates

An instructive, although rough, impression of the importance of real factors can be gained by examining how much the real exchange rate has actually varied. To do this, I computed the TOT and PPP components of several dollar exchange rates using monthly (seasonally adjusted) U.S. and foreign consumer price indices. Table 1 lists the average rate of change in these components and in the corresponding nominal exchange rate, as well as the standard deviations of these changes; the period is May 1973 through August 1980. The average change is, of course, a measure of the trend as defined earlier while the standard deviations measure the variability of changes about that trend (i.e., of changes in $e' + e^*$).[26]

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[25] For a discussion of the implications of evidence on the purchasing-power parity doctrine, see Pigott and Sweeney (1980).

Table 1 illustrates perhaps the most remarkable feature of the floating exchange rate regime begun in 1973. This is the very high variability of the real components of nominal exchange rates. Indeed, the standard deviation of changes in the real exchange rate is virtually the same as that of the nominal exchange rate changes; the pattern is, in part, a reflection of the nearly zero correlation between variations in nominal exchange rates and PPP changes that has been noted by many analysts. In contrast, the variability of the PPP components themselves is much lower, generally one quarter or less, of the standard deviation of nominal exchange rate changes.

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26. Some distortions in the behaviour of our PPP and real exchange rate measures could arise from the high sensitivity of the U.S. consumer price index to mortgage interest rates (which affect the housing cost component). Indeed, Canadian readers will notice that the CPI figures used here suggest that U.S. and Canadian inflation has been virtually the same since 1973, while if GNP deflators are used, Canada's price level shows a 20 per cent increase above that of the United States (and hence the real exchange rate, measured using GNP deflators, shows virtually no change). I chose not to use GNP deflators for the tests because they are available on a quarterly basis only. Nonetheless, it is interesting to note that Darby's (1980) estimates suggest that more than half of the changes in the Canadian real exchange rate defined in terms of GNP deflators persist in the long run, a result quite consistent with those reported here for CPI-constructed indices (see Table 1 of his paper).

TABLE 1

VARIANCE OF NOMINAL EXCHANGE RATES AND THEIR COMPONENTS[1]
(May 1973 - August 1980)

	Canada	France	Germany	Japan	U.K.	Italy
1. **Nominal Exchange Rate**						
Average change (%)	-.17	.10	.53	.18	-.07	-.42
Standard deviation[2]	1.34	3.14	3.52	3.09	2.78	2.84
2. **PPP Component**						
Average change (%)	.01	-.14	.33	-.06	.42	-.55
Standard deviation[2]	.33	.33	.36	.83	.75	.56
3. **TOT Component**						
Average change (%)	-.18	.25	.20	.24	-.49	.14
Standard deviation[2]	1.42	3.18	3.57	3.07	2.86	2.83
Memo:						
Correlation of 1&2	-.11	-.07	-.07	.15	.02	.12
Correlation of 2&3	-.34	-.17	-.17	-.12	-.24	-.08

1. Nominal exchange rates are the dollar values of foreign currency; the PPP component is the ratio of the (seasonally adjusted) U.S. to foreign CPI; the TOT component is the PPP component divided by the exchange rate.
2. Standard deviations of changes in the logarithm of the component and expressed in percentages.

3.2 The Persistence of Real Exchange Rate Changes

The above results graphically demonstrate that the task of interpreting observed exchange rate changes is essentially that of explaining variations in real exchange rates, that is changes in relative commodity prices. If we could be certain that these observed variations in real exchange rates reflected changes in their long-run values, real factors would be clearly established as the dominant influence on exchange rate variations. But of course, actual variations in the real exchange rate may also reflect movements about the long-run level.

Despite this problem, we can, in principle, measure the importance of real factors by estimating the extent to which actual real exchange rate movements have tended to persist in the long run. That is, fluctuations in x about its long-run value, x*, are by definition transient. If all variations were of this type, actual real exchange rates would exhibit a pattern whereby any current change would tend to be followed by a fully offsetting series of changes in the opposite direction. On the other hand, if real exchange rate fluctuations reflect movements in their long-run values only, actual changes in x will be essentially random, with no tendency for a current change to be followed by offsetting (or reinforcing) movements.

More generally, we can characterize the pattern of changes in the real exchange rate with a "univariate" model of the form

$$\Delta x(t) = m + a_0 z(t) + a_1 z(t-1) + \ldots + b_1 \Delta x(t-1) + b_2 \Delta x(t-2) + \ldots \qquad (6)$$

The z( ) are random disturbances reflecting the collective initial impact of all factors causing the real exchange rate to vary. Thus, z( ) reflects all factors causing movements in x about its long-run value, as well as real factors.

The "dynamics", that is, the subsequent pattern of changes the disturbances induce in x, are determined by the parameters "a" and "b". In particular, the cumulative changes in the real exchange rate following a given z(t), which equals the change in the long-run real exchange rate, are given by

$$\Delta x^*(t) = gz(t), \ g \equiv \Sigma a_i/(1 - \Sigma b_i) \qquad (7)$$

Thus, the standard deviation of changes in the long-run real exchange rate can be estimated as g times the estimated standard error of z.[27]

A drawback of this procedure is that, because z( ) represents the collective impact of factors causing x to vary, a shift in their relative importance over the estimation period could cause the model ( ) to be unstable.[28] Alternatively, consider an extension that attempts to account more explicitly for real interest rate variations. To do this, assume that anticipated inflation can be approximated as a weighted average of past inflation (estimated by regression) and that the long-term real interest rates are averages of current and past short-term real interest rates. Letting r(t)

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[27] More formally, we have a model of the form,

$$A(L) \cdot x(t) = B(L)Z(t)$$

Assuming A(L) has roots outside the unit circle, we can rewrite this as

$$x(t) = \frac{B(L)}{A(L)} Z(t) \equiv C(L)Z(t)$$

Now the sum of the changes in x resulting from a Z(t) are simply $c_0Z(t) + c_1(Z(t) + \ldots + c_n(Z(*)) = C(1)Z(t)$. But, $C(1) = B(1)/A(1)$ where $A(1) = 1 - \Sigma a$, as defined in the text. Expression (7), therefore, refers to the estimated change in the "level" or intercept of x's long-run path as calculated from the model. In estimating the model in this form, I am essentially assuming that the "trend", or average, rate of change in x is fixed during the sample.

[28] In particular, a shift in the relative importance of real interest variations after October 1979 could lead to instability in the model (6).

refer to the proxy for the short-term (3-month) real interest differential between the United States and abroad, we can then write,

$$x(t) = c + d_0\Delta r(t) + d_1\Delta r(t-1) + \ldots + a_0 z(t) + a_1 z(t-1) + \ldots + b_1\Delta x(t-1) + b_2\Delta x(t-2) + \ldots \qquad (8)$$

Here, the lagged response of x( ) to r( ) represents the direct impact of the long-term real interest differential, as well as its relation to the short-term differential.[29] If we assume that the average long-term real interest differential was constant over the sample period (i.e., the unconditional mean of changes in x* was constant), fluctuations about this mean must "cancel out" with no impact on x* itself; accordingly, we can again measure the standard deviation of x* as g times the standard deviation of z( ). It should be noted that while (8) accounts more explicitly for influences on x than the univariate model, a potentially more serious disadvantage is that the real interest proxies may not be very accurate.

The results of estimating relations (7) and (8) over the period May 1973 - August 1980 are summarized in Table 2, with

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[29] We can rewrite (8) as

$$x(t) = e + \sum_{j=0}^{\infty} d_j' r(t-j) + \sum_{j=0}^{\infty} a_j' z(t-j)$$

Clearly, though, we would arrive at a similar relation if x( ) could be written as a distributed lag on the long-term real interest differential which in turn was related to the short differential via a fixed distributed lag. This would be the case if the long-term real interest rate were determined via an adaptive expectations process applied to current and past short-term real interest rates.

the detailed parameter estimates given in the Appendix.[30] Taken as a whole, these estimates suggest that real factors have been a major influence on exchange rate variations.

Note first that the second "regression" model implies that between 60 and 100 per cent of all variations in x persisted in the long run. More important, the implied standard deviation of changes in the long-run real exchange rate ranges between 40 per cent (Canada and Italy), and 100 per cent (France, Japan and the United Kingdom) of the standard deviations of either the actual real or nominal exchange rates. Indeed, in all cases the estimated standard deviation of long-run real exchange rate variations exceeds, generally considerably, that of changes in the PPP component. The estimates from the univariate model support these general impressions, except in the case of Germany.[31]

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30. Elsewhere (Pigott, 1981), I report evidence supporting the hypothesis (advanced in Section 2) that variations in the long-run real exchange rate affect mainly the nominal exchange rate and not national price levels. I also do not report the regression used to generate the expected inflation proxies, although I will be happy to supply them upon request.

31. Particularly for Germany and France, the univariate model results are often fairly sensitive to the exact specification and sample period chosen. This may be due in part to the fact that relatively large numbers of parameters are estimated. I have estimated a fairly general model -- at the obvious risk of "over-fitting" in order to avoid losing small effects that might not show up as statistically significant. When I followed the more usual procedure of allowing lags only where the auto-correlations were relatively significant, half or more of the real exchange rate changes appear to persist in the long run in virtually all cases. On the whole, the general conclusion -- that real factors are important influences on exchange rates -- is reasonably robust, except possibly for Germany and France.

TABLE 2

SUMMARY EVIDENCE ON THE PERSISTENCE OF TOT CHANGES

	"Univariate" Model[1]						Regression Model[2]				
	$S(\Delta x)$	F^2	R^2 (unadjusted)	$S(z)$	g	$S(\Delta x^*)$	F^2	R^2 (unadjusted)	$S(z)$	g	$S(\Delta x^*)$
Canada	1.43	4.3*	.34	1.23	72%	.89	3.7	.38	1.21	62%	.75
France	3.10	2.9*	.25	2.83	36%	1.02	3.2*	.30	2.77	98%	2.72
Germany	3.36	2.2*	.21	3.16	0%	.00	2.2*	.24	3.13	64%	2.00
Japan	3.12	2.6*	.23	2.89	113%	3.26	2.5*	.32	2.91	142%	4.13
U.K.	2.88	3.9*	.32	2.52	120%	3.02	3.4*	.33	2.52	96%	2.42
Italy	2.85	2.2*	.21	2.68	83%	2.22	1.7	.23	2.68	60%	1.61

Notes:

1. The effective period for the univariate and regression models is July 1973 to August 1980, except for Japan, where the period for the regression model is July 1974 to August 1980.

2. Test of the hypothesis that all the estimated parameters (except the constant) are zero. An asterisk (*) indicates that the hypothesis (based on asymptotic) "F" distribution for the test statistic can be rejected at a 5% (or better) significance level.

3. The % of the residual (z) persisting in the long run is computed as $a_j/(1-b_1-b_2)$ where a and b refer to the estimates (see relations (3) and (4)).

4. The model specification used can be described as:

	Moving average (z) lags	Lags on Δx	Lags on Δr
Univariate model	1-6, 12	1-2	---
Regression model	1-4, 12	1-2	0-3

The real interest differentials were constructed using three-month eurocurrency rates and estimates of the anticipated CPI inflation rates, as explained in the text.

Thus, taken as a whole, these results suggest that real factors have been a very substantial, in several cases the major, source of variations in nominal exchange rates. In virtually all cases, they appear to have exceeded in importance factors leading to variation in national inflation rates. It is worth noting in this context that Darby (1980) has estimated time-series models of the form (5) for the 1971-78 period, with implications for the persistence of real exchange rate changes that are broadly consistent with the results summarized in Table 2.

3.3 Which Relative Commodity Prices Have Varied?

The above results imply that satisfactory models of exchange rate determination will have to account for long-run changes in relative commodity prices arising from real factors. Thus, it is of some interest to know the types of relative commodity price changes that have contributed to variations in x, since this may provide a clue into their origins as well as hints for simplifying the modelling process.

In order to do this, the CPIs of the United States and foreign nations were decomposed into four categories: food; all categories except food; rent; and all services except rent. The first two categories consist in large part of traded goods, while the latter two consist mainly of non-tradeables. A measure of relative U.S.-foreign (dollar) prices was then constructed for each category. The standard deviations and correlations of changes in those subcomponents of x for the United States vis-à-vis Germany, Japan and Canada are given in Table 3.

TABLE 3

STANDARD DEVIATIONS AND CORRELATIONS OF CHANGES IN COMPONENTS OF REAL EXCHANGE RATES

		Correlation with:			
	Standard deviation	Food	Other goods	Rent	Other services
Canada					
Food	1.41	--	.74	.78	.70
Other goods	1.10		--	.90	.84
Rent	1.08			--	.88
Other services	1.14				--
All goods	1.09				
Germany					
Food	3.00	--	.94	.95	.93
Other goods	2.84		--	.99	.98
Rent	2.72			--	.98
Other services	2.83				--
All goods	2.83				
Japan					
Food	2.79	--	.86	.88	.85
Other goods	2.68		--	.97	.91
Rent	2.57			--	.92
Other services	2.73				--
All goods	2.64				

Notes:

1. Each component is defined as, $p_i + e - p_i^f$, that is, as the log of the dollar price of the U.S. commodity type to the dollar price of its foreign counterpart. Note that these components comprise the first term of relation (3) in the text and hence are not an exhaustive decomposition of the real exchange rate as defined there.
2. All data are monthly, seasonally adjusted CPI components; changes are calculated as first differences of the levels (expressed in logs), expressed in percentages.
3. The period is June 1973 through December 1980.

The most notable result is that the changes in the components of x are very highly correlated. That is, changes in the real exchange rate have tended to reflect movements in the entire structure of U.S. commodity prices relative to the dollar prices of their counterparts. This pattern would be most likely to arise from disturbances to aggregate supply, or aggregate real demand in the United States or abroad, rather than mainly from factors causing changes in the relative prices of domestically produced goods.[32] Furthermore, this pattern suggests that, in modelling the exchange rate, treating each country's goods as a single aggregate (e.g., as in Stevens et al, (1979)) may be a reasonably accurate simplification.

3.4 Interest Rate Implications

Finally, we can briefly consider what, in light of the earlier discussion, the observed behaviour of interest rates suggests about the behaviour of exchange rates. A thorough examination, which would require explicit consideration of variations in the components of interest rate and exchange rate variations, is beyond the scope of this paper. Instead, I focus here on determining which of several simple stylized views about exchange rate determinants and dynamics is most consistent with the observed pattern of interest rate and exchange rate fluctuations.[33] This analysis will illustrate the arguments of the last section without exploiting them fully.

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[32] For example, if commodity supply elasticities were roughly the same and the "shocks" consisted of shifts in aggregate demand we might observe this pattern. Shifts in commodity supplies in equal proportion with homothetic demands would give a similar result. These conjectures do not make the result any less puzzling, however.

Consider first a world in which nominal exchange rates are virtually always on their long-run paths, whose levels fluctuate randomly with little or no change in their trends (Case I). There, we would expect the variance of changes in spot and forward rates to be nearly identical, and their correlation to be near unity; variations in nominal interest rate differentials (and, hence, in the difference between spot and forward rate changes) should be very small, as should their correlations with changes in spot and forward rates. Alternatively (Case II), suppose that exchange rates are generally at or near their long-run values, but that a substantial portion of the variations in the long-run path result from changes in its slope or trend, which are reflected in interest rates. Then we would expect to find spot and forward rate changes highly correlated, but the latter should be more variable than the former. In addition, the ratio of interest rate to exchange rate variability should be greater than in the first case, and interest rate changes (in favour of the United States) should be strongly positively correlated with changes in the forward dollar value of foreign currency.

The last case to consider is one in which real interest rate fluctuations about their mean caused by transient "shocks" in credit markets are the major cause of exchange rate variations. In this case, fluctuations in spot exchange rates and in interest rate differentials should be of

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[33] My analysis is similar to an earlier examination of exchange rate models by Brittain (1977), although the purpose here is (somewhat) different.

TABLE 4

SUMMARY INTEREST - EXCHANGE RATE PATTERNS SUGGESTED BY CASES I-III

	Case I	Case II	Case III
1. Relative variability of Δe to Δf	same	less	greater
2. Relative variability of Δin to Δe	zero	lower	same
3. Correlation of Δe and Δf	+1	+1	0
4. Correlation of Δe and Δin	0	0	-1
5. Correlation of Δf and Δin	0	+1	0

Notes: Δe - change in the log of the spot dollar value of foreign currency.
Δf - change in the log of the forward dollar value of foreign currency.
Δin - change in the long-term nominal interest differential in favour of the United States.

comparable magnitude, but both should considerably exceed the variability of changes in forward rates. Moreover, interest rate variations in favour of the United States should be negatively correlated with the spot dollar value of foreign currency, but should be little correlated with its forward value. This of course is the pattern there was some reason to suspect might emerge after October 1979.

In order to examine these cases, the standard deviations and correlations of (percentage) changes in spot and forward exchange rates and of their differences -- the latter closely approximating changes in the U.S.-foreign (eurocurrency) interest differential -- were computed for the floating rate interval before and after June 1979. Table 5 presents those results for Germany and Japan, where I have used weekly averages of spot and 1-year forward exchange rates. (Clearly, my use of 1-year forward rates is not strictly consistent with the earlier analysis, since it may well take more than a year for adjustments to the long run to be effected.)

TABLE 5

INTEREST RATE - EXCHANGE RATE STANDARD DEVIATIONS AND CORRELATIONS

	June 1973 - June 1979				July 1979 - August 1981			
	Standard deviation of:	Correlation with: Δe	Δf	$\Delta f - \Delta e$	Standard deviation of:	Correlation with: Δe	Δf	$\Delta f - \Delta e$
Germany								
Δe	1.05	—	.96	-.03	1.28	—	.94	-.42
Δf	1.09	—	—	.24	1.16	—	—	-.08
$\Delta f - \Delta e$	.31	—	—	—	.45	—	—	—
Japan								
Δe	.95	—	.94	.03	1.26	—	.92	-.14
Δf	1.02	—	—	.37	1.28	—	—	.23
$\Delta f - \Delta e$	.37	—	—	—	.47	—	—	—

Notes:
1. The first period for Japan is February 1974 - June 1979.
2. See Table 4 for symbol definition; $\Delta f - \Delta e$ is a close approximation of Δin. The forward values are 1-year rates. All data are computed from weekly averages of daily figures. The changes are expressed in percentages.

Clearly, it is the first case that best characterizes exchange rate behaviour before mid-1979. That is, spot and forward rate variability is virtually the same and substantially greater than that of interest rate fluctuations. Moreover, there is very little correlation between interest rate and spot exchange rate changes, although there is a higher (and positive) correlation of the former and forward rate variations. Particularly for Japan, there is thus some evidence that variations in expected inflation, reflected in the inflation premium in interest rates, have played a role (probably a modest one) in observed exchange rate fluctuations. But in either case, exchange rate behaviour is fairly consistent with the pattern that would be observed in an "efficient" market in which exchange rate changes (about their mean) are largely unanticipated, and in which adjustments to the long run are fairly unimportant.

The pattern prevailing after mid-1979 is noticeably different, particularly in the case of Germany. The variability of the spot exchange rate is now greater than that of the forward rate, while the variability of interest rate changes has increased relative to that of both exchange rates. Most revealing, there is now a substantially negative correlation between increases in the U.S.-foreign interest differential and changes in the spot dollar value of foreign currency, but almost no correlation of the differential with forward rate changes. This, of course, is the general pattern predicted by the third case in which temporary variations in real interest rates are a major determinant of exchange rates. However, the evidence certainly does not imply that real interest rates have in any sense dominated exchange rate changes since the implementation of the new Fed procedures.

Again, these conclusions are based on limited evidence and are highly tentative. More complex patterns of changes in real and nominal interest rates could produce patterns similar to those of the above cases, yet have very different implications for the determinants of exchange rates and for their dynamics. Such possibilities do not really invalidate the theoretical analysis of Section 3, but they do imply that all its implications need to be drawn on if the factors affecting exchange rates are to be identified.[34]

4 In conclusion, this paper has attempted to describe how real, monetary, and (other) financial influences interact to determine exchange rates in the long and the short run. I have argued that, ultimately, exchange rates can be regarded as the product of factors determining relative commodity prices and those determining national price levels. Observed movements of exchange rates can then be viewed as reflecting shifts in these long-run determinants, the adjustments to the long run these factors induce, and transient fluctuations about the long run produced by temporary supply-demand imbalances in financial markets and (possibly) other factors. Moreover, where the mobility of capital is very high, both the long-run determinants of exchange rates and their short-run

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[34] In particular, if fluctuations in real interest rates were largely offset by changes in inflation premiums in the opposite direction, the pattern of exchange rate and interest rate fluctuations could be very similar to that of Case I. (Such a negative correlation between expected inflation and the real interest rate is, of course, that predicted by the Dornbusch 1976 model.) However, this more complex case differs from Case I in that it implies that real exchange rate changes will be serially correlated, whereas Case I implies that they will be random. More generally, such analyses of *contemporaneous* changes in interest rates and exchange rates, while suggestive, are subject to serious limitations. Brittain's analysis, for example, can be said to rule out Dornbusch "overshooting" as the *exclusive* cause of observed exchange rate variations; but when there are *multiple* sources of exchange rate variation it generally cannot identify the relative importance of each. To do so, we are apt to have to use information about the serial correlation of exchange rates and interest rates in a more general framework where they are estimated *jointly*.

dynamics are largely reflected in the behaviour of interest rates.

The most important and basic conclusion of the analysis is that real factors are very substantial influences on exchange rates, empirically as well as theoretically. Real factors affect exchange rates because the "constraint" on average price levels imposed by money stocks and the demands for them effectively forces the adjustment to relative price changes onto the foreign exchange markets. In a sense, then, exchange rates are subject to more disturbances than are price levels, and for this reason it is not very surprising that exchange rates have varied more than their PPP components. Moreover, this view is as widely applicable as the monetary theory of the price level on which it is based. It does not require that we view exchange rates as determined in asset markets in the short run, or that capital be highly mobile. It is likely to be as relevant for developing countries and those without sophisticated domestic financial institutions as for the major industrial nations. Thus, the results presented in Section 3 suggesting that real factors have accounted for a large portion of the dollar's variability since 1973 -- and other supporting evidence in the literature -- are of fairly general significance.

The second portion of the analysis implies that, when capital mobility is very high, variations in interest rates and exchange rates are intimately related, and indeed can be viewed as different aspects of common adjustments in commodity and asset markets. As the illustrative empirical analysis given at the end of Section 3 suggests, the observed pattern of interest rate fluctuations can reveal a good deal, not only about the dynamics of exchange rates, but about their ultimate determinants as well. More generally, these relations allow us to draw on the considerable body of (not unambiguous) analysis and evidence pertaining to interest rate determination in interpreting actual exchange rate behaviour. Of course, this analysis is not nearly as general as the first because it applies only when exchange rates can be viewed as determined in relatively free and sophisticated financial markets. This limits its applicability to nations with substantial controls on capital and relatively underdeveloped financial markets.

Finally, what practical lessons for the modelling of exchange rates might be drawn from the analysis and evidence? Certainly, the most obvious is that relative price influences on exchange rates must be explicitly accounted for in explaining nominal exchange rates. Models that fail to do this, the evidence suggests, neglect what may be the single largest source of exchange rate variations, or at the least confuse real factors with other exchange rate determinants. Very likely, such models will provide an inadequate if not misleading depiction of the effects of government policies on exchange rates, since these policies will often affect relative commodity prices.

More generally, builders of future macroeconomic models may find it more fruitful and more convenient to model the real exchange rate rather than the nominal rate. This at least would focus efforts on determining the sources of relative price influences on exchange rates, which are almost certainly much less understood than are the determinants of the PPP component. Such a procedure would also exploit the models of price levels and inflation already embedded in most macroeconometric models. Given foreign price levels, these equations effectively explain the PPP component. Why then repeat this process in a more implicit fashion in an exchange rate model?

In fact, a modeller could go even further and (where capital mobility is high) exploit the interest rate relations that are also contained in many macroeconomic models. That is, such models usually "explain" a variety of nominal interest rates and have implications for real interest rates as well. In principle, these implications could be used to determine the transient component of the real exchange rate, leaving the analyst free to focus on the long-run real exchange rate. Plainly, given a detailed enough model of the domestic economy, we could go even further and dispense with the explicit modelling of exchange rates altogether. While I would not suggest that such a course is either practical or desirable, it does illustrate that the task of modelling exchange rates cannot be sensibly divorced from that of understanding the domestic economic conditions they reflect.

APPENDIX

TABLE A-I

PARAMETER ESTIMATES FROM UNIVARIATE MODEL

Variable/ Country	Canada	France	Germany	Japan	U.K.	Italy
Δx(t-1)	.29(.12)	.87(.15)	1.14(.16)	-1.34(.27)	.43(.02)	-.64(.05)
Δx(t-2)	-.64(.12)	-.29(.13)	-.58(.14)	.64(.27)	-.94(.03)	-.91(.05)
d(t-1)	.44(.15)	1.13(.16)	1.42(.19)	-1.43(.30)	.52(.10)	-.56(.13)
d(t-2)	-.64(.15)	-.66(.23)	-.92(.25)	-.78(.38)	-1.16(.12)	-.93(.14)
d(t-3)	-.16(.13)	.13(.18)	.30(.21)	-.22(.20)	.15(.17)	.11(.15)
d(t-4)	.11(.13)	-.15(.17)	-.08(.21)	-.42(.21)	.02(.17)	.11(.16)
d(t-5)	-.18(.12)	.04(.18)	.16(.19)	-.38(.22)	-.26(.12)	.05(.14)
d(t-6)	.06(.10)	.31(.12)	-.04(1.12)	-.05(.15)	.12(.11)	.08(.12)
d(t-12)	.40(.09)	.05(.08)	.16(.06)	-.10(.06)	-.21(.06)	.02(.08)
Std Error	1.23	2.82	3.16	2.89	2.53	2.68
Q-orig.	16.7	8.7	10.1	5.3	15.0	3.0

Notes:

1. The Δx() are the autoregressive terms; the d are the moving average elements. Standard error estimates are in parentheses.

2. Q-orig. is the (Box-Pierce) test statistic for the first 12 autocorrelations of the original series (the 5% critical value is 21.0).

3. The coefficients of the moving average terms correspond to $-a_1$, $-a_2$, etc. of relation (7) in the text, with a_0 normalized to equal unity.

TABLE A-II

PARAMETER ESTIMATES OF THE REGRESSION MODEL

Variable/ Country	Canada	France	Germany	Japan	Italy	U.K.
$\Delta r(t)$	.11(.15)	-.15(.15)	.83(.12)	-.22(.20)	-.02(.6)	-.12(.12)
$\Delta r(t-1)$	.28(.16)	.23(.15)	-1.60(.15)	.23(.28)	.02(.06)	.14(.13)
$\Delta r(t-2)$	-.08(.17)	-.05(.16)	1.35(.24)	.42(.30)	.08(.07)	-.07(.14)
$\Delta r(t-3)$	.29(.17)	-.01(.16)	-.24(.20)	.57(.22)	0.00(.07)	.06(.14)
$\Delta x(t-1)$	.21(.17)	.04(.22)	1.29(.08)	-.89(.08)	.45(.12)	.38(.07)
$\Delta x(t-2)$	-.44(.13)	-.65(.12)	-.77(.08)	-.70(.09)	-.55(.15)	-.85(.04)
$d(t-1)$	.34(.16)	.25(.16)	1.62(.08)	-1.09(.04)	.56(.14)	.38(.12)
$d(t-2)$	-.38(.15)	-.82(.16)	-1.30(.10)	-1.03(.07)	-.68(.16)	-1.03(.04)
$d(t-3)$	-.18(.12)	.15(.12)	.32(.13)	-.24(.11)	.14(.12)	.28(.11)
$d(t-4)$	0.00(.11)	-.20(.11)	.04(.09)	-.04(.10)	.04(.12)	0.00(.06)
$d(t-12)$	.46(.10)	.05(.09)	.01(.04)	-.26(.07)	.26(.10)	-.07(.04)

Notes:

1. Test that the set of parameters is equal to zero.
2. Period is July 1973 - August 1980 except for Japan, where it is October 1974 - August 1980.
3. $\Delta r()$: change in the estimated 3-month real interest differential in favour of abroad; $d()$: moving average term; $\Delta x()$: change in the log of the real exchange rate.
4. Figures in parentheses are standard error estimates.
5. The coefficients of the moving average terms correspond to $-a_1$, $-a_2$, etc. of relation (8) in the text, where a_0 is normalized to equal unity.

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DISCUSSION

John Taylor noted that in Hooper and Tryon's simulations, whereas real output is little affected by OPEC portfolio behaviour, exchange rates are affected a great deal. This raises the question of whether the responsiveness of output in the model to changes in the real exchange rate is too low. Furthermore, realized and expected exchange rates can apparently differ substantially in the model so that there are systematic unexploited profit opportunities. Hooper agreed that rational expectations are not imposed. Assets are not assumed to be perfect substitutes so that, other things equal, a higher expected rate of return on dollar-denominated assets is required to induce investors to increase their net holdings of dollar-denominated assets. Slangor was concerned about the use of the import price in domestic energy consumption equations, since the price confronted by consumers may be very different as a result of government policy. Hooper responded that for Canada the domestic producer price was used; for other countries the estimated effect on consumption of the world oil price increase will be unbiased if the elasticity of domestic to import prices is constant over time.

Hang Sheng Cheng thought that Anne McGuirk's results were reasonable, but wondered if it might be possible to gauge the reliability of the IMF's MERM by doing some goodness-of-fit tests on past data. He also queried the monetary policy assumptions, which seem to accommodate cost increases, in consequence of which the price level movements and nominal exchange rate movements underlying the change in real exchange rates are not clear. McGuirk responded that it would be very difficult to do goodness-of-fit tests of a meaningful kind with MERM. Parameters are imposed a priori. As for prices, they are determined by market clearing conditions, and monetary policy does not play an accommodating role in their determination.

Helliwell warned that it was not easy to compare results from the two papers. The high OPEC absorption case for the MCM is closest to the MERM experiment. However, the latter would have to be scaled down since it includes both OPEC price shocks whereas the MCM experiments include only the second shock. Also, McGuirk deals with energy in general while Hooper and Tryon deal only with oil. Both models show a significant real depreciation of the yen and a significant real appreciation of the pound. On the other hand the Canadian dollar and the German mark depreciate in the MCM and appreciate in MERM. The appreciation of the mark in MERM 2 seems to be related to a high OPEC propensity to import German manufactures. Longworth put forward the explanation that the stronger Canadian dollar in McGuirk's paper as compared with Hooper and Tryon's is due to the fact that Canada starts with a surplus in energy trade as a whole, but a deficit in oil trade.

As a postscript to the Conference, McGuirk and Hooper agreed to run a consistent experiment, the results of which are presented following this discussion.

With respect to the paper by Pigott, Bruce White suggested that a regression of the nominal exchange rate on current and lagged purchasing-power parity would yield residuals that could be taken to represent movements in the terms of trade. This would provide a more vigorous derivation of the "terms-of-trade component" of the exchange rate than the differences in trends used by Pigott. Longworth observed that results on standard deviations in Table 5 of the paper tended to contradict Dornbusch's "overshooting" hypothesis in that the variance of the spot rate was less than the variance of the forward rate in three out of four cases. Longworth's own results for the Canadian dollar were more favourable to the hypothesis.

COMMON EXPERIMENT[1]

The different structures and objectives of the MCM and the MERM make it difficult to perform exactly the same experiment. The MCM is designed for the shorter run analysis of alternative macro policies, taking into account the interaction among the economies of the major industrial countries. It is composed of linked macro models with well-developed financial sectors and is very much concerned with cyclical analysis. In contrast, the MERM is a general equilibrium trade model with no explicit financial sector. It is designed for the longer run analysis of the effects of relative price changes and as such assumes a policy stance that offsets the cyclical effects of disturbances.

While it is not possible to perform the same experiment, since the models cannot be solved holding the same things constant, it is possible to compare the results for the same current account shock. We have chosen the shock corresponding to Case 4 of the MCM simulations. This case corresponds most closely to the assumptions regarding the disposition of the OPEC surplus used in MERM. The size of the "oil shock" and the corresponding changes in real exchange rates for the two models are summarized in the following table.

In this experiment the net effect of higher oil prices on the trade account is shown in column (1). These trade balance effects must be adjusted for net capital inflows, column (2), resulting from the disposition of the remaining OPEC surplus to determine the total balance of payments effects, column (3). Estimates of the changes in real exchange rates induced

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[1] This postscript to the Conference compares and contrasts the results of a common experiment performed with MCM and MERM.

COMPARISON OF MCM AND MERM SIMULATIONS

	Net oil exports	Net capital inflow*	Total BOP effect	Changes in real exchange rate	
				MCM	MERM
	(1)	(2)	(3)	(4)	(5)
Canada	- 2.5	.2	- 2.3	- 5.9	- 0.8
United States	-31.0	10.0	-21.0	0	0
Japan	-31.5	1.9	-29.6	-11.0	- 6.3
Germany	-17.2	3.6	-13.6	-13.5	- 7.0
United Kingdom	3.7	1.1	4.8	18.0	10.2

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* Capital inflows for each country equal the size of the OPEC surplus at the end of the period for MCM Case 4, 21.3 billion U.S. dollars, distributed based on the 1980 investment pattern of OPEC.

by these balance of payments effects derived from the MCM and the MERM are shown in columns (4) and (5), respectively. The results indicate that the real exchange rates of Canada, Japan and Germany depreciate relatively more vis-à-vis the U.S. dollar and the pound in the MCM simulations than in the MERM simulations. This may be due to the output effects of higher oil prices in the MCM. In the United States real GNP is 7 per cent lower than in the control solution by the end of the period, compared to small changes in real GNP for Japan, Germany and Canada. Real GNP in the United Kingdom also falls significantly, by 5 per cent. Lower activity in the United States and the United Kingdom reduces the demand for the exports of their trading partners, depressing those currencies relatively more than in the MERM case where real output is held constant in all countries. Interestingly, the relative positions of the currencies that depreciate against the U.S. dollar are more or less the same in the two simulations.

The much larger appreciation of the pound in the MCM simulations can be explained by two effects which do not play a role in the MERM, namely, the expectations effect and the portfolio balancing effect. In the MCM, the large current account surpluses experienced by the United Kingdom lead to revised expectations regarding the equilibrium path of the exchange rate for the pound. An estimate of the magnitude of this effect for the MCM simulation can be obtained using the impact multipliers in the paper by Hooper and Tryon, page 65. The 38.8 billion U.S. dollar cumulative current account surplus of the United Kingdom by the end of the simulation period could add almost 8 per cent to the appreciation of the pound. In the very short run, to keep portfolios balanced (that is, for the stock of foreign assets to be willingly held), the pound must appreciate still further, inducing expectations that foreign currencies will appreciate against the pound.

Once the differences between the MCM and MERM simulations are taken into account, the results are not that different. The relative positions of the depreciating currencies are about the same, the stronger position of the dollar being explained by cyclical effects. Further, the much larger appreciation of the pound in the MCM results is explained by expectational and financial variables that affect the adjustment path rather than a difference in the long-run equilibrium value.

3 COUNTRY MODELS

SUPPLY SHOCKS AND MONETARY RESPONSES IN KOREA: A PROGRESS REPORT

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1 INTRODUCTION

During 1980 the Korean economy, which had begun to show signs of sluggishness from the latter half of 1979, experienced unprecedented negative GNP growth, a higher rate of inflation, and a deterioration in the balance of payments. This recession is attributable to the fact that the sharp energy price increases that have occurred since late 1979 have profoundly affected the Korean economy. It is also due to a poor grain harvest and such non-economic factors as temporary socio-political instability.

In particular, the increase in the price of energy resources relative to the price of business output reduced potential output and productivity and changed the optimal capital intensity of production which, in turn, temporarily slowed real business investment in 1980. Higher energy prices also had temporary effects on total spending and employment.

In the formulation of stabilization programs, attention has been focused primarily on the effects of the financial variables on aggregate demand and their implications for the balance of payments. In contrast, this paper is concerned with an analysis of the implications of credit policies for production and how they relate to the development of the current account and the price level. It is well known that availability of credit is one of the factors that determine final demand in an economy. To the extent that domestic production of goods and services responds to changes in aggregate demand, one could characterize these output effects as being indirectly induced through credit policies. A direct connection between the level of current production and credit availability exists because of the need for firms to finance the cost of inputs for the duration of the production process, including the time required to sell the product. Production plans of the firm, the number of workers hired, and the size of the inventory of finished and intermediate goods and raw materials held by the firm are affected by the amount and terms of credit.

Tight credit policies affect the cost of credit, either directly, or as is more likely in most developing countries with administered lending rates and rationed bank credit, by driving firms into the unorganized money market. This transmission channel feeds directly from monetary policy into the supply side of the economy.[1] We incorporated into our model the hypothesis that restrictive credit policies result in: (i) disintermediation in the organized market; and (ii) resort to the unorganized money market for the financing of primary input costs.

In addition to the incorporation of the effects of credit policies on the supply side, the present paper also suggests a macro-framework for the analysis of import price shocks and the stagflationary effect of devaluation. In particular, the paper addresses the following issues: (i) Is it possible to bring inflation down in the short run and/or in the long run via a restrictive credit policy under import price shocks? (ii) Does currency devaluation result in stagflation in the economy through the channel of credit restriction and higher interest rates?

Our discussion here will be based on a modified version of the short-term forecasting model of the Korean economy developed by the Bank of Korea.[2] Section 2 gives a brief

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1. See Bruno (1979).

2. Hyun Chul Shin and Dae Sik Kim (1981).

account of the basic structure of the model and the underlying price and output adjustment theory that is a core topic in this paper. Section 3 analyzes empirical results based on dynamic simulation with the stagflationary effects of devaluations and relative import price changes providing the main perturbations. Section 4 suggests improvements which could be made to the present formulation of the model.

2 THE MODEL

2.1 Basic Structure of the Model

A very simple and abstract theoretical model of an open economy characterized by the presence of financial constraints is developed in this section. The model consists of four blocks: (i) the GNP block; (ii) the financial block; (iii) the price block; and (iv) the balance of payments (BOP) block. In the GNP block, output is composed of GNP in the agriculture, forestry and fishing (AFF) sector and non-AFF GNP. The former is assumed to be exogenous owing to the difficulty of endogenization since agricultural production is heavily affected by weather conditions and damages incurred through blight and harmful insects. A major component of the theoretical framework to be used here for formalization of the non-AFF GNP equation follows from a commodity market theory of price and output adjustment by firms under monopolistic competition. A detailed derivation of aggregate price and output adjustment relations from such microfoundations is given elsewhere.[3] Here, the model will be modified to take into account an element that seems to be of key importance, namely, the role of working capital and credit rationing.[4] Specifically, the output decision is based on a model of the firm that starts from the assumption that primary costs (wages and costs of intermediate inputs) are financed via credit. The interest rate that is relevant for the cost of credit is considered endogenous. The role of the interest rate and credit will be discussed in the explanation of the financial block.

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[3] Bruno (1979).

Real gross expenditure consists of private consumption expenditure, private non-residential investment, private residential investment, inventory investment, government expenditure (government consumption and construction), net exports of goods and non-factor services, and net factor income from the rest of the world. Among these, private consumption expenditure is explained by real income and real total money balances, while non-residential investment is determined by non-agricultural output, domestic credit and the cost of credit.

While real government expenditure is determined exogenously, net exports of goods and non-factor services are determined in the BOP block. The net exports of factor services are treated as exogenous variables. What if planned supply falls short of or surpasses actual demand? Where inventory holdings exist, output can be assumed to be equal to planned output with inventories adjusting to any temporary discrepancies. Inventory investment is an adjusting item for commodity market clearing in the model.

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4. This has been analyzed in the context of the finance of physical capital by McKinnon (1973) and Shaw (1973). Our approach here centres on the finance of variable inputs and has greatly benefited from the very interesting recent studies by Bruno (1979) and Keller (1980).

In the financial block, the total money stock (M2) is assumed to be exogenous. The linkage between the real and monetary sectors is through domestic credit to the private sector and the curb market interest rates in addition to the total money stock.

The most descriptive adjective for credit markets in developing countries is "segmented". One source of finance is always the official banking system, perhaps with controlled interest rates and hidden costs such as requirements that borrowing firms keep minimum balances on deposit. Another source would be unorganized markets. For residual finance, firms go to the riskier informal credit market where the interest rate is sensitive to the volume of borrowing demand. This implies that the effective borrowing cost is a function of the pegged official interest rate and the credit supply, as well as factors affecting the supply of credit through the informal market.

In the price block, we adopted a method in which the wholesale price (WPI) is determined first and in turn influences the GNP deflator. With reference to the determination of the WPI, the model allows for both demand pressure and cost-push effects. The theoretical basis for this is the simultaneous determination of price and output described above in the GNP block.

Exports and imports of goods and services are determined in the balance of payments block, where real GNP, WPI, the net export unit price index, the exchange rate and world trade volume act as important explanatory variables.

2.2 Data and Estimation Method

The model has been estimated over 48 quarters from 1967Q1 to 1978Q4. All GNP-related variables are based on 1975 prices. We limited the estimation period to 1978 to leave 1979-1980 available for an ex-post forecast check. To variables that are subject to seasonal variation, an X-11 adjustment was applied. Ordinary least squares estimation was used.

For certain periods for which there were large discrepancies between estimates and actual values that could be attributed to changes in the structure of the economy, we applied dummy variables.

3 SIMULATION RESULTS

In this section, we report a variety of simulation exercises performed to study some of the properties of the model.

To find a solution to the model, we relied on the Gauss-Seidel method which is commonly used in simulations of non-linear econometric models. The results of dynamic simulation with this method from 1975Q1 to 1979Q4 are shown in Table 1. As is evident from this table, ex-post simulation results for important variables are, on the whole, satisfactory.

The fact that non-residential investment shows a somewhat sizeable discrepancy compared with other variables, should be interpreted in the light of the usual difficulties of econometric estimation of investment behaviour, which are due mainly to the underlying characteristics of investment demand. In addition to its considerable variance, investment demand is not only responsive to economic fluctuations, but is also heavily influenced by non-economic factors. On the other hand, estimation of exports and imports produced favourable results in view of their heavy dependence on foreign factors.

TABLE 1

RESULTS OF HISTORICAL SIMULATION: 1975Q1-1979Q4

	RMSE	Mean	RMSE(%)
GNP	366.40	12,326.47	3.02
Non-agricultural GNP	364.10	9,736.37	3.31
Private consumption	137.10	8,184.63	1.73
Non-residential investment	227.63	2,889.62	8.24
Exports	300.42	4,590.30	6.03
Imports	352.34	5,821.36	6.14
Domestic credit to the private sector	116.45	6,013.22	1.39
GNP deflator	0.074	1.425	4.32
Wholesale price index	5.27	126.44	4.12

Domestic credit extensions to the private sector, the GNP deflator and the WPI were explained satisfactorily.

As the ability of the model to trace actual movements in the key macro variables is confirmed by the dynamic simulation both within and beyond the sample period, we can proceed to the effects of supply-side disturbances and policy changes in order to see certain characteristics of the model. A substantial part of the recent escalation of inflation was attributed to foreign influences. Such supply shocks confront monetary policymakers with a dilemma. To the extent that such major price increases were due to foreign influences, it appeared that they could not be immediately prevented by domestic monetary restraint. The central bank was urged by some to accommodate the foreign-induced price increases, that is, to supply the monetary growth needed to sustain the higher prices resulting from foreign influences so as to maintain the normally desirable path of output and employment. An alternative option would be monetary restraint to put downward pressure on all domestic prices until the foreign-induced increases in the domestic price level were offset, with the possibility of a prolonged period of economic slack and reduced output. A third option is a compromise strategy, such as maintaining the previous target path of growth of the nominal GNP, with a somewhat higher price level and somewhat lower output and employment. The proper conduct of monetary policy in the face of such developments remains an unsettled issue.[5]

We tried to analyze and compare the multiplier effects of these policy choices with simulations of the model. Four types of simulation exercise were performed for the period from the first quarter of 1976 through the fourth quarter of 1979. The price shock and the other simulations of the model were as follows:

SIM 1: The import unit price index was increased by 10 per cent above the actual data.
SIM 2: The exchange rate was increased by 10 per cent above the actual data.
SIM 3: The total money stock (M2) was increased by 10 per cent above the actual data under the case of SIM 1.
SIM 4: The total money stock (M2) was decreased by 10 per cent from the actual data under the case of SIM 1.

Table 2 indicates the results of the simulations in terms of selected macroeconomic variables as a per cent change from control.

The permanent 10 per cent increase in the import unit price index causes wholesale prices to increase by 5.3 per

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[5] See Gramlich (1979).

TABLE 2

SIMULATION RESULTS
Shock - control, %

	GNP				GNAG			
	SIM 1	SIM 2	SIM 3	SIM 4	SIM 1	SIM 2	SIM 3	SIM 4
Year 1	-0.43	-0.25	-0.30	-0.56	-0.56	-0.38	-0.42	-0.70
Year 2	-0.42	-0.26	-0.28	-0.56	-0.54	-0.39	-0.40	-0.69
Year 3	-0.43	-0.30	-0.28	-0.58	-0.55	-0.44	-0.49	-0.72
Year 4	-0.45	-0.34	-0.29	-0.51	-0.56	-0.48	-0.49	-0.73
Year 5	-0.46	-0.38	-0.29	-0.52	-0.56	-0.51	-0.48	-0.74

	PW				XGS			
	SIM 1	SIM 2	SIM 3	SIM 4	SIM 1	SIM 2	SIM 3	SIM 4
Year 1	5.30	5.34	6.21	5.39	-0.17	4.50	-0.17	-0.17
Year 2	5.78	5.89	6.66	5.89	-0.29	6.60	-0.28	-0.29
Year 3	5.85	6.06	6.70	5.99	-0.34	6.72	-0.33	-0.35
Year 4	5.86	6.12	6.69	6.02	-0.36	6.83	-0.35	-0.36
Year 5	5.86	6.21	6.68	6.04	-0.35	6.82	-0.34	-0.35

	MGS			
	SIM 1	SIM 2	SIM 3	SIM 4
Year 1	-3.12	-3.13	-2.71	-3.84
Year 2	-2.09	-2.11	-1.84	-3.11
Year 3	-1.73	-1.57	-1.20	-2.77
Year 4	-1.57	-1.44	-1.02	-2.61
Year 5	-1.47	-1.37	-0.92	-2.53

cent in the first year and by an additional 0.45 per cent in the second year. The rapid rise in price level reduces real money holdings, depressing consumption and investment on the expenditure side. Higher import prices work only indirectly to reduce real exports by way of effects on the export unit value index due to higher domestic price levels. There is a decrease in real imports of 3.12 per cent in the first year, but imports do not decline significantly thereafter. The immediate decline can be explained by a fall in real income in addition to the direct relative price effect. After the first year, the relative domestic price rise discourages further substitution away from imports. A decrease in consumption, investment and exports reduces domestic demand and tends to cause real GNP to fall. On the supply side, the repercussions of the non-agricultural GNP work directly to reduce output by 0.55 per cent on average. This reflects both the foreign disturbance and a rise in the marginal borrowing cost. In our model, the unofficial market interest rate is positively dependent on foreign price levels as has already been discussed. As a consequence of combined negative responses from both the demand and supply sides, the real GNP declines by 0.44 per cent on average.

Consider the effects of an increase in the exchange rate of the won per U.S. dollar (i.e., a devaluation) by 10 per cent. As a devaluation resembles an increase in foreign prices, its effects are similar to those described above. Thus, the same framework could be used in order to work out the effects. However, they are not symmetrical in their effects on real exports. One of the key factors that determines the effect of a discrete change in the exchange rate of a country on its trade balance is the effect on that country's costs and prices. The larger the rise in money costs, domestic prices, and export prices (in domestic currency) that is induced by a devaluation, the smaller will be the competitive price advantage achieved by the country from the devaluation and, hence, the smaller will be the improvement in the trade balance.

There is an immediate and permanent improvement in the trade balance in the devaluation simulation. Real exports increase by 4.5 per cent by the end of the first year following the devaluation and by 6.7 per cent on average thereafter. Furthermore, real imports decrease by 3.13 per cent in the first year owing to the increase in import costs, but they do not continue to fall owing to changes in relative prices between domestic price levels and import prices in domestic currency.

By and large, the effect of a devaluation shows itself in a cost-push influence on the wholesale price level (increase) and on the supply of output (decrease). It can now be seen how an exchange rate change will affect domestic prices and output in the model. The exchange rate enters the equations for wholesale prices and non-agricultural GNP jointly with the import price index. Both equations have a number of interesting implications for cost increases, growth, and inflation. An increase in import prices caused by a devaluation causes credit requirements to grow owing to cost increases. This forces more borrowers to the curb market, even keeping credit constant, thus raising marginal borrowing costs. Increases in import costs and interest rates increase the inflation rate and reduce output growth. This implies that stagflation in the economy is the result of devaluation. These predictions are in general agreement with what one expects in a semi-industrialized economy like Korea.

Real balance (absorption) effects at work in our model, owing to to higher domestic prices, serve to depress consumption and investment. There is a faster rate of increase in domestic prices by 5.9 per cent on average and a reduction in real GNP by 0.25 per cent in the first year and 0.3 per cent on average thereafter.

Price shocks from the supply side can occur even at low levels of aggregate demand. Standard remedies for dealing with supply-side inflation are not necessarily appropriate.

We introduced an exogenous disturbance (increase in import prices) and made alterations in monetary policy. In our model, changes in monetary growth directly influence consumption through changes in real cash balances and indirectly influence investment through changes in domestic credit to the private sector. Changes in credit also change the interest rate, which affects the supply side. The simulation exercises clarify some of the quantitative implications of different monetary policy responses to the foreign disturbance.[6] One interesting result is the poor performance of the restrictive monetary policy. It is ineffective because it has a weak anti-inflationary effect and reinforces the cost-push stagflationary influences on the economy. We can interpret this fact as the result of the existence of a segmented domestic money market. Its existence implies that a monetary contraction could be expected to have a stagflationary effect coming from the supply side, quite independently of any subsequent demand effects. It is important to note the role played by financial costs in the equations for wholesale prices and non-agricultural GNP in reinforcing the stagflationary effect. Policies restricting money supply growth will not necessarily be anti-inflationary since the increase in interest rates that they induce will drive prices up. Rather, the brunt of the resulting credit restriction falls on output. Short-run orthodoxy in a semi-industrialized economy may have price effects precisely opposite to those usually assumed for an advanced economy.

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[6] We refrain from making any judgements concerning which policy would be most effective in a global sense, since effectiveness would vary according to the magnitude of the policy package, the range in which the magnitude can change, and the initial conditions. Therefore, any empirical results must be interpreted with these elements in mind.

In practice though, "what policymakers should do" is not so straightforward as our results imply. Perhaps our most important finding is that whatever the monetary response, shocks are very costly. If their impact on output is minimized by increasing money supply growth, the shock-induced inflation can linger for several years. If their inflationary impact is minimized by a restrictive policy, the cost in terms of low output and high inflation is sizeable. Various intermediate approaches are possible, but all result in some combination of persistent slower growth, higher inflation or both. If nothing else, this shows scope for policies other than macro responses to minimize price shocks.

4 CONCLUDING COMMENTS

In this paper, we have used a short-term forecasting model of the Korean economy to simulate the effects of changes in import prices, devaluation, and monetary responses to foreign disturbances on selected macroeconomic variables.

Several caveats are required. First, the level of employment and wages is exogenous to the model. This is an important limitation, as no feedback on the level of prices from the depressed output is permitted through labour markets and wage costs. Second, explicit incorporation of government distributional policies towards hard-hit sectors might be advisable. Third, we employed aggregate net export functions, but in practice trade is composed of very heterogeneous commodities. Separate equations for different types of goods would increase the realism of the model.

It is a universally acknowledged truth that even in industrial economies where conflicting interests are adjusted and reconciled through a free-market mechanism, the econometric model has serious limitations. In an economy like Korea's where production and distribution are heavily influenced by government regulation and by monopoly, these limitations are magnified. We are in a period of great change in the management of the Korean economy from government-led to private-centred with increased emphasis on private business and the free-market mechanism. This trend can be expected to increase the applicability of econometric models. An ongoing research effort is crucial if the model is to reflect adequately the characteristics of the ever-changing economic structure.

Although the model simulations may not fully replicate the real world, they may nevertheless be viewed as an illustrative application of a technique applicable to developing countries. This is the intended contribution of the paper.

APPENDIX

A SHORT-TERM FORECASTING MODEL OF THE KOREAN ECONOMY[7]

GNP BLOCK

1 Definitional Equations

1(a) Gross National Product

$$\begin{aligned} GNP = {} & CON + IME + IFPH + II + XGS - MGS + \overline{XFI} \\ & - \overline{MFI} + \overline{G} + \overline{SD} \end{aligned}$$

1(b) Inventory investment

$$\begin{aligned} II = {} & GNAG + \overline{GAG} - (CON + IME + IFPH + XGS - MGS \\ & + \overline{XFI} - \overline{MFI} + \overline{G} + \overline{SD}) \end{aligned}$$

2 Behavioural Equations

2(a) Private consumption expenditure

$$\begin{aligned} \ln CON = {} & \underset{(2.6378)}{0.52419} + \underset{(2.5749)}{0.169631} \ln GNP + \underset{(2.16)}{0.0349391} \ln\left(\frac{M_2}{PGNP}\right) \\ & + \underset{(8.1096)}{0.73411} \ln CON_{-1} \end{aligned}$$

$$R^2 = 0.9959 \qquad D.W. = 1.9586$$

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[7] All equations are estimated by OLS; t-values are given in parentheses.

2(b) Private non-residential investment

$$\mathrm{IME} = \underset{(-0.92)}{-162.65} + \underset{(2.86)}{1.608} \sum_{i=1}^{4} \left[\frac{\mathrm{DCP}}{\mathrm{PW}} - \left(\frac{\mathrm{DCP}}{\mathrm{PW}}\right)_{-1} \right]_{-i} \Big/ 4$$

$$+ \underset{(4.55)}{0.1815}\ \mathrm{GNAG} - \underset{(-1.48)}{0.1596}\ \mathrm{RP} + \underset{(3.93)}{0.5677}\ \mathrm{IME}_{-1}$$

$$- \underset{(-4.39)}{422}\ \overline{\mathrm{IFPD}}$$

$R^2 = 0.9692$ D.W. = 1.68

2(c) Private residential investment

$$\mathrm{IFPH} = \underset{(-1.8745)}{-112.45} + \underset{(2.2286)}{462.15} \sum_{i=1}^{3} \left(\frac{\mathrm{GNP}}{\mathrm{POP}}\right)_{-i} \Big/ 4 + \underset{(9.2202)}{0.83199}\ \mathrm{IFPH}_{-1}$$

$$- \underset{(-3.4310)}{100.27}\ \overline{\mathrm{DH13}} + \underset{(2.5307)}{145.44}\ \overline{\mathrm{DH23}}$$

$R^2 = 0.9340$ D.W. = 2.3130

2(d) Non-agricultural GNP

$$\ln \mathrm{GNAG} = \underset{(3.08)}{4.4196} - \underset{(-2.22)}{0.08542} \ln \left(\frac{\overline{\mathrm{PMGI}} \cdot \overline{\mathrm{FXSA}}}{\mathrm{PW}}\right)$$

$$- \underset{(-2.16)}{0.09223} \ln \mathrm{RP} + \underset{(2.43)}{0.47056} \sum_{i=1}^{3} \ln \mathrm{GNP}_{-i} \Big/ 3$$

$$+ \underset{(3.6)}{0.017}\ \mathrm{T}$$

$R^2 = 0.9946$ D.W. = 1.78

FINANCIAL BLOCK

1 Definitional Equations

1(a) Domestic credits to the private sector

$$DCP = M_2 - NFA - \overline{NOT}$$

2 Behavioural Equations

2(a)

$$NFA = \underset{(0.1323)}{0.35081} + \underset{(30.725)}{0.00021271}\,(OB \times \overline{FXSA}) + \underset{(100.81)}{0.9656}\,\overline{NFA}_{-1} - \underset{(5.2719)}{91.022}\,\overline{DWR24} + \underset{(7.1281)}{84.139}\,\overline{DF23}$$

$$R^2 = 0.9962 \qquad D.W. = 1.9775$$

2(b) Curb market interest rates

$$RP = \underset{(7.4)}{23.03} + \underset{(9.43)}{1.19495}\,RT - \underset{(-1.89)}{3.968}\,\left(\frac{DCP}{GNAG}\right) + \underset{(1.013)}{0.023}\,\frac{(\overline{PMGI}\cdot\overline{FXSA})_{-1}}{(\overline{PMGI}\cdot\overline{FXSA})_{-5}} - \underset{(-2.55)}{4.1928}\,\overline{DRP1}$$

$$R^2 = 0.8603 \qquad D.W. = 1.893$$

PRICE BLOCK

1 Wholesale prices

$$\begin{aligned}\ln(PW) = {} & \underset{(-9.43)}{-2.68896} + 0.3618^{*}\ln(\overline{PMGI}\cdot\overline{FXSA}) \\ & + \underset{(1.29)}{0.10733}\ln\left(\frac{\overline{WR}\cdot\overline{EMP}}{GNAG}\right) + \underset{(3.60)}{0.1478}\ln(RP) \\ & + \underset{(3.60)}{0.262876}\ln(PW_{-1}) \\ & + \underset{(1.83)}{0.111496}\ln\left(\frac{\sum_{i=1}^{4} GNP_{-i}\ PGNP_{-i}}{4}\right) - \underset{(-3.42)}{0.0972}\,\overline{DPW}\end{aligned}$$

$R^2 = 0.9932$ D.W. = 0.6865

2 GNP deflator

$$\begin{aligned}\ln(PGNP) = {} & \underset{(-5.53)}{-0.412312} + \underset{(2.57)}{0.7274}\ln(PW) \\ & + \underset{(1.35)}{0.386491}\ln(PW_{-1}) - \underset{(-2.93)}{0.118583}\,\overline{DPGNP}\end{aligned}$$

$R^2 = 0.9906$ D.W. = 0.4709

3 Export unit value index

$$\begin{aligned}\ln PXGI = {} & \underset{(15.8)}{6.0285} + \underset{(3.69)}{0.2508}\ln PW - \underset{(-10.0)}{0.8794}\ln\overline{FXSA} \\ & + \underset{(9.36)}{0.538}\ln\overline{TWMV}\end{aligned}$$

$R^2 = 0.9818$ D.W. = 1.779

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* Parameter value imposed, derived from input-output analysis.

BALANCE OF PAYMENTS BLOCK

1 Definitional Equations

1(a) Over-all balance

$$OB = XVD - MVD + \overline{RES}$$

2 Behavioural Equations

2(a) Exports of commodities and non-factor services

$$XGS = \underset{(-0.22792)}{-17.325} + \underset{(1.3413)}{0.16482}\ \overline{FSXE} \cdot \left(\frac{\overline{PEIW}}{PXGI}\right)$$

$$+ \underset{(1.3167)}{0.0032983} \sum_{i=1}^{4} (\overline{TWMV} \cdot \overline{FXSA})_{-i/4} + \underset{(15.317)}{0.9272}\ XGS_{-1}$$

$R^2 = 0.9913$ D.W. $= 1.5376$

2(b) Imports of commodities and non-factor services

$$MGS = \underset{(-2.0862)}{-649.89} - \underset{(-2.8283)}{1.8277} \sum_{i=1}^{2} \left(\frac{\overline{PMGI} \cdot \overline{FXSA}}{PW}\right)_{-i/2}$$

$$+ \underset{(5.6997)}{0.3156}\ (GNP+MGS) + \underset{(1.9011)}{0.27872}\ MGS_{-1}$$

$R^2 = 0.9856$ D.W. $= 1.7141$

3 Exports and Imports Conversion Equations (from constant won to current U.S.$)

3(a) Exports of commodities and non-factor services

$$XVD = \underset{(0.69111)}{-3.4353} + \underset{(1334.1)}{1.0015}\ (XGS \cdot \overline{PX}/\overline{FXSA}) \cdot 100$$

$R^2 = 1.0$ D.W. = 1.8501

3(b) Imports of commodities and non-factor services

$$MVD = \underset{(0.042896)}{0.31915} + \underset{(1100.7)}{0.99978}\ (MGS \cdot \overline{PM}/\overline{FXSA}) \cdot 100$$

$R^2 = 1.0$ D.W. = 2.1109

LIST OF VARIABLES

Endogenous Variables

GNP	Gross National Product (constant billions[8])
CON	Private consumption expenditure (constant billions)
IME	Private non-residential investment (constant billions)
IFPH	Residential investment (constant billions)
II	Inventory investment (constant billions)
XGS	Exports of commodities and non-factor services (constant billions)
MGS	Imports of commodities and non-factor services (constant billions)
GNAG	Non-agricultural GNP (constant billions)
PGNP	GNP deflator (1975=1.0)
PW	Wholesale price index (1975=100)
PXGI	Export unit value index (1975=100)
NFA	Net foreign assets of monetary institutions (billions)
DCP	Domestic credit to private sector (billions)
RP	Curb market interest rates (% p.a.)
XVD	Exports of commodities and non-factor services (millions of dollars)
MVD	Imports of commodities and non-factor services (millions of dollars)
OB	Over-all balance (millions of dollars)

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[8] At 1975 constant market price, in billion won.

Exogenous Variables

$\overline{XFI}$	Exports of factor services (constant billions)
$\overline{MFI}$	Imports of factor services (constant billions)
$\overline{POP}$	Population, 14 years and over (thousands of persons)
$\overline{M}$	Money supply (billions)
$\overline{RT}$	Interest rate on time deposits (% p.a.)
$\overline{NOT}$	Other assets (billions)
$\overline{FXSA}$	Exchange rate of won to U.S.$ (won)
$\overline{FXSE}$	Exchange rate of won to U.S.$ including export subsidy (won)
$\overline{WR}$	Daily earnings in manufacturing industry (won)
$\overline{EMP}$	Employed population aged 14 years and over (thousands of persons)
$\overline{RES}$	Over-all balance except trade balance (millions of dollars)
$\overline{PX}$	Export deflator (1975=1.0)
$\overline{PM}$	Import deflator (1975=1.0)
$\overline{PEIW}$	Export price index of world manufactured goods (1970=100)
$\overline{PMGI}$	Import unit value index (1975=100)
$\overline{TWMV}$	World imports (billion won)
$\overline{G}$	Government expenditure (constant billions)
$\overline{SD}$	Statistical discrepancy (constant billions)
$\overline{GAG}$	Agricultural GNP (constant billions)
$\overline{IFPD}$	Dummy variables (1975Q3=1, 0 otherwise)
$\overline{DH13}$	Dummy variables (1973Q1 and 1975Q2, Q3=1, 0 otherwise)

Exogenous Variables (continued)

$\overline{DH23}$	Dummy variables (1977Q3=1, 0 otherwise)
$\overline{DWR24}$	Dummy variables (1975Q1=1, 0 otherwise)
$\overline{DIF23}$	Dummy variables (1976Q4 and 1977Q2=1, 0 otherwise)
$\overline{DRP1}$	Dummy variables (1972Q3, Q4 and 1973Q1, Q2=1, 0 otherwise)
$\overline{DPW}$	Dummy variables (1973Q4=1, 0 otherwise)
$\overline{DPGNP}$	Dummy variables (1974Q3 and 1975Q3=1, 0 otherwise)

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SUPPLY DISTURBANCES AND MONETARY RULES IN AN OPEN ECONOMY: SOME EMPIRICAL RESULTS

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The analysis and conclusions in this paper are those of the author and are not necessarily shared by the Reserve Bank of Australia.

1 INTRODUCTION

Since 1975 macroeconomic modelling in the Reserve Bank of Australia has concentrated on relatively small models.[1] However, the relationships that are modelled cover the major aspects of the economy. The approach is similar to that advocated in a different context by Lindbeck (1977, p.1) when he said:

> When approaching the theory of the balance of payments, exchange rates, and stabilisation policy, it is easy to agree that the analysis ideally should be pursued in the context of a complete macro model with consideration to the interaction of various markets.

This paper sets out some of what has emerged from this modelling exercise. It reviews in Section 2 the difficult and relatively neglected area of modelling the balance of payments. Then in Section 3 some simulation results for three supply-side disturbances are examined. Section 4 discusses briefly the results of two studies that examine the sensitivity of the results to assumptions about the setting of the exchange rate. The paper concludes with some general comments on strategies for modelling the economy.

2 THE EXTERNAL SECTOR OF THE RBII MODEL

As well as including an equation to explain the behaviour of the exchange rate, the balance of payments sector of RBII is modelled more completely than in many other models.[2] The model includes equations for real exports and imports, for the price of exports and for net capital flows. This treatment is important for explaining changes in the stock of money. Movements in the quantity of money are modelled from the sources or supply side, that is, as the sum of changes in foreign reserves, the budget deficit less changes in non-bank take-up of government securities, and changes in bank advances.[3] This procedure allows the supply of money to differ from the quantity of money demanded. The excess demand or supply of money plays an important role in the adjustment dynamics of RBII.[4]

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[1] These models are generally called the RBII models.

[2] The RDX2 model of the Canadian economy also has an extensive balance of payments sector.

The exchange rate in RBII is modelled as a policy reaction function, as set out in equation (17) of the model specification which is given as an Appendix to this paper.[5] In this regime the authorities are assumed to "manage" the exchange rate so that in the long run, purchasing-power parity is achieved, but in the short run, movements in the exchange rate are influenced by other variables. Endogenizing the exchange rate seems essential for medium-term analysis, particularly if a country has had experience with rates of inflation different from those in the rest of the world.

Expectations of changes in the exchange rate enter the various demand equations for financial assets and liabilities in the model and the equation for the commercial bill rate (a short-term market determined rate of interest). The financial assets/liabilities in the model are money, bonds, net

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3. See Stammer (1978) for a discussion of this approach to the formation of money.

4. See Jonson (1978) for a discussion of money and the modelling of that role in RBII.

5. Helliwell (1979) provides a survey of alternative ways of modelling movements in the exchange rate.

Australian capital owned by overseas residents, and bank advances. Expectations of changes in the exchange rate formed by economic agents are modelled by a process that could be termed "sensible". That is, expectations of changes in the exchange rate are assumed to be based on incomplete information. The relevant information set consists of two parts: first, the assumption that the authorities aim to achieve purchasing-power parity in the long run; and second, an exogenous component (QE) which reflects the buildup in expectations that occurs when the exchange rate changes in a discrete manner (that is, the expectations roughly parallel the specification of the actual exchange rate equation).

The equation for exports allows for a partial response to changes in relative prices and world demand, and to a measure of inventory disequilibrium. The role of inventories is as a buffer stock of producers and hence its role in the export equation suggests that if there is an excess supply in the domestic goods market, then producers will try to increase exports. The estimated rate of adjustment of exports to demand is fast; the effect of relative prices on export demand is estimated to be low.[6]

Real imports and domestic output are linked via a simple representation of the aggregate supply decision that allows for a partial response to changes in relative prices and expected sales. Imports are also influenced by measures of inventory disequilibrium and deviations of actual sales from expected sales.

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[6] The determination of exports is one of the least satisfactory parts of the model. It is an area where a disaggregated approach may be required.

For imports, the adjustment lags are longer than for exports but relative price effects are much stronger. These factors combine to give a J-curve response to changes in the exchange rates but this exists only for one or two quarters.

Import prices in U.S. dollars are exogenous but their value in Australian dollars depends on the $A/$U.S. exchange rate. Export prices depend partly on domestic demand pressure but adjust fairly quickly to changes in world prices and in the exchange rate.

A feature of the external sector of the model is that the stock of net foreign-held capital adjusts fairly slowly to a desired value. The desired value of net foreign-owned Australian assets depends on income and the differential between Australian and foreign interest rates (with allowances for expectations about changes in the exchange rate). As is the case for many countries, the speed of response of capital flows is an unresolved issue for Australia.[7]

3 SOME SIMULATION RESULTS

A recent paper by Jonson and Trevor (1981) has examined the responses of the RBII model to a variety of exogenous shocks. The responses were compared for the cases where monetary policy followed one of three simple rules. The paper examined the proposition, set out by Poole (1970), that it is more sensible to control the volume of money when the shocks are "real" and to control the interest rate when the shocks are "financial".

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[7] Once again evidence generated in the RDX2 project is important. It suggests relatively fast adjustment for capital flows in Canada. See, for example, Helliwell and Maxwell (1972, 1974).

Among the shocks considered by Jonson and Trevor are three that could be termed supply-side shocks. They consist of:

(i) a sustained increase of 5 per cent in minimum wages;
(ii) a sustained reduction of 2 per cent in capacity output;
(iii) a sustained increase of 5 per cent in world prices.

The alternative regimes for monetary policy consist of:

(i) a rigid bond rate. In this regime, the degree of monetary accommodation is usually high.
(ii) partially accommodating money. The bond rate that responds positively to monetary expansion but allows some monetary accommodation.
(iii) tight money. The bond rate responds sufficiently to monetary expansion or contraction so that the degree of monetary accommodation is virtually zero except in the first three or four quarters.

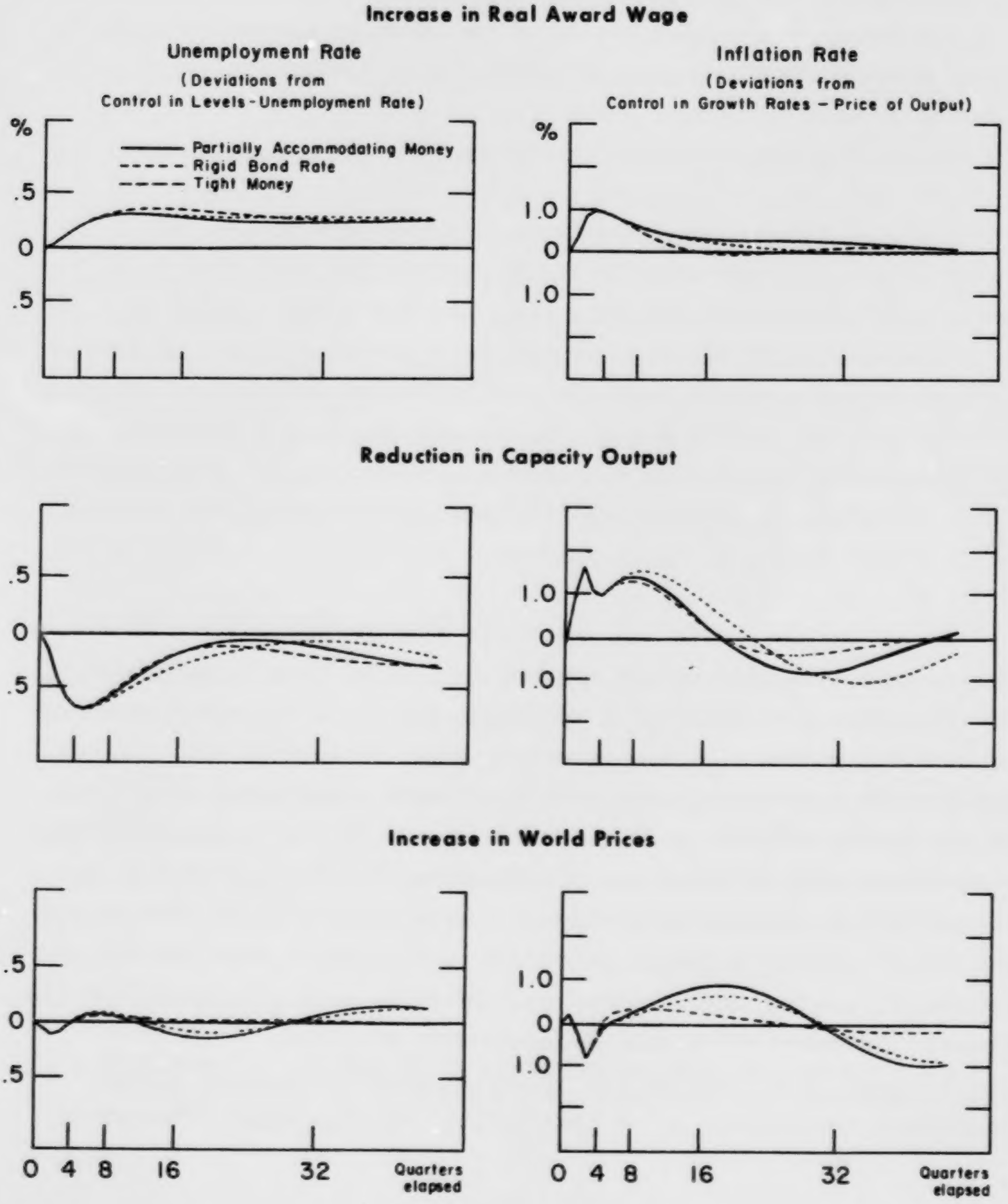
In all cases it is assumed that the exchange rate is relatively fixed in the short run but adjusts to purchasing-power parity in the long run. That is, the estimated reaction function for the exchange rate is used.

Figure 1 compares the effect of each impulse on the rate of inflation and the unemployment rate. These graphs show the deviations of the shock solutions from the control solutions of inflation and the unemployment rate. They thus illustrate the relationship between inflation and unemployment in the decade following the shocks, providing a useful summary of the dynamic properties of the model.

In each panel there are three simulation paths; these represent the effect of a particular impulse under the three

Figure 1

UNEMPLOYMENT AND PRICE RESPONSES: SUPPLY SHOCKS



Increase in Real Award Wage

Unemployment Rate (Deviations from Control in Levels - Unemployment Rate)

Inflation Rate (Deviations from Control in Growth Rates – Price of Output)

Reduction in Capacity Output

Increase in World Prices

regimes for monetary policy. The unbroken lines represent the outcome with the estimated bond rate reaction function, the short dashes represent the case in which the bond rate is fixed and the long dashes represent the case of tight money.

The impact effects of the various shocks are similar for each regime of monetary policy. Each of the basic impulses initially raises the price level and hence the rate of inflation, and the money supply rises in the short run in most cases.

Initially, consider the outcomes of the various shocks with partially accommodating money. For the first of the supply-side shocks, which is a *rise in minimum wages*, money wages respond more strongly and more quickly than prices, the growth of real product is reduced, and unemployment rises. The growth of money accelerates in response to a fall in the bond rate (induced mainly by the rise in unemployment) and a slight improvement in the balance of payments (due mainly to a decline in imports). This increased monetary growth helps to underwrite the increases in money wages. In the long run the price level rises by 2.8 per cent, real output rises by only .7 of 1 per cent and unemployment is increased by .3 of 1 per cent.

With a *cut in capacity output*,[8] prices are influenced directly by the rise in the unit cost of labour. The implied cut in the marginal product of labour initially cuts money wages, although this reaction is quickly reversed by the response to rising prices. Nevertheless, real wages fall and a decline in unemployment follows. The rise in the growth of money is much smaller than the rise in inflation and, together with a deterioration of the current account, this puts a downward squeeze on real product. The long-run result is higher prices (2.5 per cent), lower product (-2.2 per cent) but higher employment; unemployment is reduced by .3 of 1 per cent.

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[8] Which could be induced by a once-and-for-all reduction in productivity or by the effective loss of part of the capital stock.

An increase in world prices produces a rapid rise in international reserves. In the short run, the effect of this on money is offset by a reduction in domestic credit due to increased sales of government bonds to the non-bank groups and decreased bank lending, these latter responses being due to expectations of a revaluation. An initial slight rise in the domestic price level is followed by a fall owing to the initial reduction in the money supply. After about a year, however, the growth of money is above the control solution value and a sizeable domestic inflation is generated. During the complex cyclical responses that follow, both inflation and unemployment are, respectively, above and below their control solution values, although in the long run they return to their control values. In the long run, the only effect is on the level of the exchange rate.

For the alternative monetary rules the following can be noted. The variability of unemployment is reduced slightly by controlling the growth of money for the shocks to capacity output and world prices. When the shock is an increase in minimum wages, controlling money makes the peak effect on unemployment slightly higher than it is when the impulse is accommodated. In no case does the response of unemployment vary by much according to the regime for monetary policy. In RBII there is little monetary policy can do to offset the real effects of the nine disturbances considered by Jonson and Trevor (1981). For most of the supply shocks, including the disturbances illustrated here, the effects on employment (and output) are sizeable.

In contrast to unemployment, the longer run response of inflation varies more obviously with different regimes for monetary policy. For all impulses, the amplitude of the cycles in inflation is reduced when the growth of money is controlled. In the short run, however, the direct effects of the shocks dominate the model's responses and in each case a sizeable increase in prices results even when money is controlled.

3.1 Underwriting

One of the main ways that tight monetary policies might improve the performance of the economy is by preventing shocks. The RBII model can be used to illustrate the potential importance of this point.

The solid line in Figure 2 shows the combined effect of two shocks -- an increase in minimum wages followed three years later by a rise in the saving ratio. In each case monetary policy is assumed to be partially accommodating. Inflation expands and unemployment increases, in both cases substantially. It will be recalled that, in the earlier analysis, tight money moderated inflation in the medium term following a wages shock at the cost of a short-term rise in unemployment. As shown by Jonson and Trevor (1981) a similar result holds in RBII for an exogenous rise in the saving ratio. For neither shock, however, does the different response of monetary policy make a great difference to the response of unemployment.

There is however a fair bit of evidence that inflation and related uncertainty have acted to raise the saving ratio in

Australia (although the precise reasons for this are not fully understood). In the simulation path represented by the dashed line in Figure 2 it is assumed that tight money is maintained when the increase in wages occurs and that, as a result, a later rise in the household saving ratio does not occur. In this case, tight money produces a substantial medium-term benefit for both inflation and unemployment.

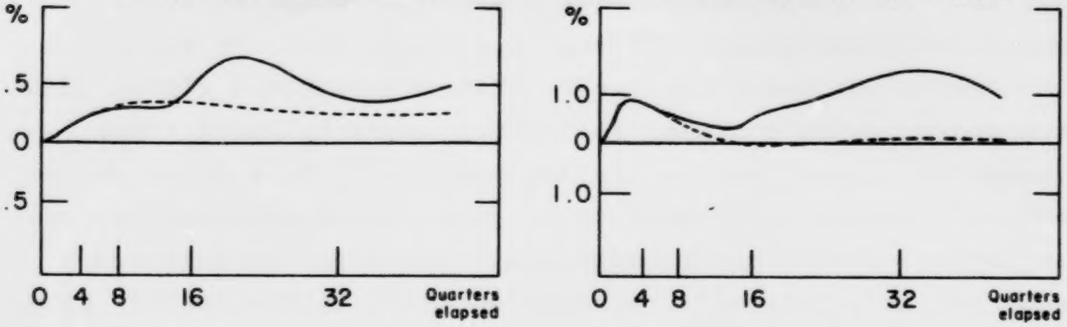
Figure 2

UNDERWRITING

Unemployment and Price Responses:
Increase in Minimum Wages and Rise in Saving Ratio

Unemployment Rate
(Deviations from
Control in Levels - Unemployment Rate)

Inflation Rate
(Deviations from
Control in Growth Rates - Price of Output)



This example illustrates the potential importance of not underwriting inflationary shocks. It cannot easily be proved that refusing to underwrite such shocks will have the beneficial results in the real world that it does in the model -- indeed how to test for such effects is not at all obvious.

4 SOME FURTHER SIMULATION RESULTS

In another recent paper, Jonson, McKibbin and Trevor (1981) examine the responses of the RBII model with alternative assumptions about how the exchange rate is set. It will be recalled that in the analysis discussed in Section 2, the estimated reaction function determined the response of the exchange rate. An alternative regime is one in which the responsiveness of the authorities in managing the exchange rate to stabilizing the level of foreign reserves is increased. While this procedure does not give the authorities complete control of the level of foreign reserves in the short term, it does approximate a floating exchange rate regime.

An analysis of the stability properties of this model suggests that the move to greater flexibility leads to instability in the model unless the speed with which capital moves across the exchanges and the speed with which agents form their expectations of changes in the exchange rate increase.

Among the shocks considered in this analysis are a shock to minimum wages and a shock to world prices; in each case it is assumed that the authorities follow a non-accommodating monetary policy. For the first of these shocks, the main influences of different assumptions in the foreign exchange market are on the timing of price effects.

For the external impulse (a rise in world prices), the exchange rate plays a more important role. The results of this shock for the case of a managed float were discussed in Section 2. With a more flexible exchange rate regime, the exchange rate initially overshoots slightly.[9] This initial overshoot is followed by a series of short-term fluctuations in the exchange rate. These are reflected in short-term variations in other variables.

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[9] Although in the long run both exchange rate regimes lead to a 5 per cent revaluation, the exchange rate under the floating regime reaches equilibrium much more quickly.

Jonson et al argue that these fluctuations can be attributed to the method of formation of exchange rate expectations in RBII. The argument is similar to that outlined for a simpler model by Laidler. Laidler shows that, in the short run, the extent to which a flexible exchange rate can insulate domestic output and inflation from foreign nominal shocks (such as a world price shock) depends crucially on the formation of expectations. For other shocks, overshoots are more serious, especially if expectations about changes in the exchange rate adjust slowly.

For RBII, in the first period after the shock the formation of expectations of exchange rate changes is dominated by the rise in world prices. There is thus an expectation of a revaluation which leads to a net capital inflow. It also leads to a fall in domestic credit owing to falling advances and an increase in the demand for bonds. There is then a further revaluation which dominates the rise in world prices in its influence on expectations. Thus a devaluation becomes expected. This leads to an outflow of capital and a rise in reserves and money. The bond rate also fluctuates to offset the monetary effects of swings of both reserves and domestic credit.

After approximately two years, the bond rate settles down to a lower level than under the managed float regime. The lower bond rate can be attributed to the initial overshoot of the exchange rate which largely eliminates the monetary consequences of the incipient buildup of reserves.

The floating exchange rate also leads to less variation in inflation (except in the first year) compared to the case of the managed exchange rate. This is not surprising since the direct and monetary consequences of a rise in world prices are prevented from feeding into the domestic price level by the rapid revaluation of the exchange rate. Output initially fluctuates because the world price effects are not perfectly offset in the short run by changes in the exchange rate. However, these effects are small and have virtually disappeared after four years.

Taylor (1981) analyzes the responses of RBII to a shock in world prices for the cases when the exchange rate is assumed to be managed by the authorities (managed float) and when the exchange rate is assumed to be freely floating. Given the growing amount of interest being paid to expectations in the recent macroeconomic literature, some alternative expectations mechanisms for the exchange rate, including rational expectations, are also considered.

One of the conclusions of this study is that shifts in expectations mechanisms are relatively unimportant compared to traditional channels in transmitting the impact of a shock under differing exchange rate regimes.

A general conclusion from both the studies examined in this section is that the domestic economy may not be insulated from short-term fluctuations in inflation and activity even with a flexible exchange rate.

5 THE WAY AHEAD

The papers reviewed above suggest the value of simulation analysis. It is true that a switch in the behaviour of the authorities, for example in setting the exchange rate, may change the reactions of economic agents -- as argued persuasively by Lucas (1977). While this seems sensible, many commentators have gone much further and interpreted the Lucas point as throwing some doubts on the validity of results from existing models. This seems inappropriate for at least two reasons. First, the point presumably only applies if the change in policy was a complete surprise and if for that or some other reason agents no longer use the past as a basis for forming expectations. Second, what it does suggest is not that existing models should be scrapped but that a range of results conditional on different possible reactions of economic agents should be provided.

The studies have also emphasized the advantages of relatively complete models, even if they are relatively simple in their specification, for examining policy issues over a medium to long horizon. The role of reaction functions is important here even if by their very nature they are more likely to be subject to shifts in the size of their parameters.

APPENDIX: THE RBII MODEL

I DYNAMIC EQUATIONS

Household expenditure

$$\text{Dlog}\, P_d d = \underset{(5.2)}{.46}\, (\log \hat{Pd} - \log P_d d) - \underset{(-2.2)}{.12}\, (\log \hat{Pm} - \log M) \qquad (1)$$

RMSPE1 = 1.24, *RMSPE2* = 3.62

Rate of growth in business fixed capital stock

$$Dk = \underset{(6.0)}{1.24}\, (\hat{k} - k) \qquad (2)$$

RMSE1 = .003, *RMSE2* = .003

Rate of growth in labour demand

$$Dl = \underset{(6.1)}{3.79}\, (\hat{l} - l) + \underset{(4.7)}{.54}\, (\log y - \log \bar{y}) - \underset{(-4.0)}{.02}\, Q_1 \qquad (3)$$

RMSE1 = .007, *RMSE2* = .006

Exports

$$\text{Dlog}\, x = \underset{(7.1)}{2.47}\, (\log \hat{x} - \log x) - \underset{(-3.2)}{1.29}\, (\log \hat{v} - \log v) \qquad (4)$$

$$+ \underset{(4.1)}{.33}\, QDS$$

RMSPE1 = 8.48, *RMSPE2* = 6.88

Imports

$$\text{Dlog}\, i = \underset{(3.4)}{.29}\, (\log \hat{i} - \log i) + \underset{(2.7)}{.53}\, (\log \hat{v} - \log v) \qquad (5)$$

$$+ \underset{(3.5)}{2.29}\, (\log e - \log e^{e})$$

RMSPE1 = 6.55, *RMSPE2* = 9.74

Output

$$\text{Dlog}\, y = \underset{(5.4)}{2.14}\, (\log \hat{y} - \log y) + \underset{(4.9)}{.99}\, (\log \hat{v} - \log v) \qquad (6)$$

$$- \underset{(-5.5)}{.08}\, (\log e - \log e^{e})$$

RMSPE1 = 2.62, *RMSPE2* = 3.16

Price of output

$$\text{Dlog}\, P = \underset{(4.1)}{.53}\, (\log \hat{P} - \log P) + .13\, (\text{Dlog}\, P_x - (\lambda_2 - \lambda_1)) \qquad (7)$$

$$- \underset{(-4.9)}{.33}\, (\log \hat{Pm} - \log M) + \underset{(3.0)}{.15}\, (\log \hat{v} - \log v)$$

RMSPE1 = 1.35, *RMSPE2* = 6.50

Price of government current expenditure

$$\text{Dlog}\, P_g = \underset{(4.4)}{.96}\, (\log \hat{P}_g - \log P_g) \qquad (8)$$

RMSPE1 = 2.63, *RMSPE2* = 10.19

Price of exports

$$\text{Dlog}\, P_x = \underset{(6.3)}{1.34}\, (\log \hat{P}_x - \log P_x) + \underset{(3.4)}{.59}\, (\log \hat{v} - \log v) \qquad (9)$$

RMSPE1 = 3.59, *RMSPE2* = 6.75

Average weekly earnings

$$\text{Dlog}\, W = \underset{(4.4)}{.45}\, (\log \hat{W} - \log W) + \underset{(10.1)}{.69}\, \log L/\phi_0 \hat{N} \qquad (10)$$

$$+ \underset{(5.0)}{.14}\, \log (w_A/w_0 e^{\lambda_5 t})$$

RMSPE1 = 1.06, *RMSPE2* = 7.30

Labour supply

$$\text{Dlog}\, N = .13\, (\log \hat{N} - \log N) + \underset{(7.4)}{.26}\, \log L/\phi_0 N \qquad (11)$$

RMSPE1 = .40, *RMSPE2* = 2.38

Non-bank demand for government securities

$$\text{Dlog}\, B = \underset{(5.2)}{.11}\, (\log \hat{Pb} - \log B) + \underset{(4.6)}{2.78}\, (Dr - Dr_w) \qquad (12)$$

$$- \underset{(-0.7)}{.06}\, (\log \hat{Pm} - \log M)$$

RMSPE1 = 1.53, *RMSPE2* = 5.99

Net foreign held capital

$$\text{Dlog}\, F = \underset{(5.9)}{.18}\, (\log \hat{Pf} - \log F) + \underset{(3.8)}{.69}\, (Dr_{bl} - Dr_{eu}) \qquad (13)$$

$$- \underset{(-4.3)}{.01}\, Q_t - .01\, QF_1 + .16\, QF_2$$

RMSPE1 = 1.86, *RMSPE2* = 8.78

Bank advances

$$\text{Dlog}\, A = \underset{(7.4)}{.19}\, (\log \hat{A} - \log A) + \underset{(4.3)}{.17}\, (\log \hat{Pm} - \log M) \qquad (14)$$

$$- \underset{(-4.1)}{.03}\, QA + \underset{(2.6)}{.02}\, QF_1$$

RMSPE1 = 1.34, *RMSPE2* = 7.39

Bill rate

$$Dr_{bl} = \underset{(3.3)}{.16}\, D\hat{r}_{bl} + \underset{(3.9)}{.14}\, (\hat{r}_{bl} - r_{bl}) - \underset{(-3.6)}{.15}\, \text{Dlog}\, M/\phi A \qquad (15)$$

$$+ \underset{(16.0)}{.04}\, Q_r$$

RMSE1 = .005, *RMSE2* = .012

Bond rate

$$Dr = \underset{(8.7)}{.03}\, (\hat{r} - r) + \underset{(10.2)}{.01}\, QS + \underset{(3.1)}{.07}\, \log L/\phi_0 N \qquad (16)$$

$$- \underset{(-3.6)}{.003}\, \log R/\theta_0 N - \underset{(-.82)}{.002}\, (\text{Dlog}\, R - \lambda_2)$$

RMSE1 = .002, *RMSE2* = .011

Exchange rate

$$\text{Dlog}\, E = \underset{(4.1)}{.04}\, (\log \hat{E} - \log E) + \underset{(11.6)}{.10}\, QUS + \underset{(12.5)}{.06}\, QER \qquad (17)$$

$$- \underset{(-3.6)}{.43}\, \log L/\phi_0 N - \underset{(-3.2)}{.01}\, \log R/\theta_0 N$$

$$- \underset{(-1.9)}{.03}\, (\text{Dlog}\, R - \lambda_2)$$

RMSPE1 = 1.00, *RMSPE2* = 5.11

Direct taxes

$$\begin{aligned} D\log T_1 = {} & \underset{(6.4)}{.62}\,[\underset{(4.3)}{.33}\,(\log \hat{T}_{11} - \log T_1) \\ & + \underset{(2.1)}{.32}\,(D\log \hat{T}_{11} - \lambda_2)] \\ & + (1 - \underset{(6.4)}{.62})(D\log t_5\, CTB - \lambda_2) \end{aligned} \tag{18}$$

RMSPE1 = 3.86, *RMSPE2* = 11.14

Indirect taxes

$$\begin{aligned} D\log T_2 = {} & \underset{(2.7)}{.15}\,(\log \hat{T}_{21} - \log T_2) \\ & + \underset{(5.7)}{.14}\,(\log \hat{T}_{22} - \log T_2) \end{aligned} \tag{19}$$

RMSPE1 = 3.80, *RMSPE2* = 5.03

Foreign reserves

$$DR = P_x x - EP_i i + DF \tag{20}$$

RMSPE1 = 7.17, *RMSPE2* = 48.31

Domestic credit

$$\begin{aligned} DC = {} & P_g g_1 + Pg_2 + Po + I - T_1 \\ & - T_2 - DB + DA + DMISC \end{aligned} \tag{21}$$

RMSPE1 = 1.07, *RMSPE2* = 9.12

Volume of money

$$DM = DR + DC \tag{22}$$

RMSPE1 = .92, *RMSPE2* = 5.51

Inventories

$$Dv = y + i - s - sd \tag{23}$$

RMSPE1 = 1.11, *RMSPE2* = 3.68

Expected sales

$$\begin{aligned} D\log (s^e/s_0 e^{\lambda_1 t}) = {} & .5\,(\log (s/s_0 e^{\lambda_1 t}) \\ & - \log (s^e/s_0 e^{\lambda_1 t})) \end{aligned} \tag{24}$$

RMSPE1 = .28, *RMSPE2* = 1.70

Business fixed capital stock

$$DK/K = k \tag{25}$$

RMSPE1 = .18, *RMSPE2* = 2.82

Labour demand

$$DL/L = l \tag{26}$$

RMSPE1 = .34, *RMSPE2* = 1.97

II EXPRESSIONS FOR DESIRED VALUES AND TECHNICAL RELATIONSHIPS

$$\begin{aligned} \log P\hat{d} = {} & d_0 + 1.0 \log (Py - T_1 + Po) \\ & - \underset{(-2.5)}{.28}\,(r - 4.0\, D\log P) \end{aligned}$$

$$\begin{aligned} \hat{k} = {} & \lambda_1 + \underset{(3.3)}{.11}\,(4.0*0.3\,\frac{(\hat{y}-g_1)}{K} - r + 4.0\, D\log P) \\ & - \underset{(-4.0)}{.46}\,(D\log P - (\lambda_2 - \lambda_1)) \end{aligned}$$

$$\hat{l} = (\lambda_1 - \lambda_4) + \underset{(6.9)}{.19}\,((1 - .3)\frac{(\hat{y})}{L} - .81\frac{W(1 + t_4)}{P})$$

$$\bar{y} = y_0 e^{\lambda_3 t} L^{(1 - .3)} K^{.3}$$

$$\log \hat{x} = x_0 + 1.0 \log x_w - \underset{(-2.3)}{.12} \log (P_x/EP_w)$$

$$\hat{i} = [i_0(\frac{EP_i(1 + t_3)}{P})^{\underset{(-6.1)}{-.78}}]s^e$$

$$\hat{y} = [1 - i_0(\frac{EP_i(1 + t_3)}{P})^{\underset{(-6.1)}{-.78}}]s^e$$

$$\hat{v} = v_0[s^e - g_1]\, e^{\lambda_6 t}$$

$$s = d + x + DK + g_1 + g_2 + g_3$$

$$\hat{P} = P_0\,(\frac{1}{1 - .3})\,\frac{WL}{\bar{y}}$$

$$\hat{P}_g = P_{g_0}\, W^{\underset{(23.7)}{.80}}\, P^{\underset{(23.7)}{(1 - .80)}}$$

$$\hat{P}_x = P_{x_0}(EP_{wl})^{\underset{(12.7)}{.14}}(EP_i)^{\underset{(12.7)}{(1 - .14)}}$$

$$P_d = P_{d_0}(EP_i)^{.2}(P)^{(1 - .2)}$$

$$\hat{W} = W_0(1 - .3)\,\frac{P\bar{y}}{L}$$

$$\log \hat{N} = N_0 + \underset{(0.6)}{.05} \log \frac{W(1 - t_1)}{P_d W_0 e^{\lambda_4 t}} + \log Z$$

$$\begin{aligned} \log \hat{m} = {} & m_0 + 1.0 \log y - \underset{(-2.9)}{2.70}\, r - \underset{(-2.6)}{2.13}\, r_w \\ & + \underset{(1.1)}{.38}\, r_{bl} + \underset{(0.8)}{.06} \log EP_w/P - .01\, QE \end{aligned}$$

$$\log \hat{b} = b_0 + 1.0 \log y + \underset{(4.2)}{14.79} (r - r_w) + \underset{(8.2)}{1.77} \log EP_w/P$$

$$- \underset{(-.9)}{.10}\, QE$$

$$\log \hat{f} = f_0 + 1.0 \log y + \underset{(5.4)}{5.37} (r_{bl} - r_{eu})$$

$$+ \underset{(4.3)}{.77} \log EP_w/P - \underset{(-1.3)}{.08}\, QE$$

$$\log \hat{A} = A_0 + 1.0 \log (1 - h)M - \underset{(-4.7)}{5.32} (r - r_w)$$

$$- \underset{(-5.4)}{.60} \log EP_w/P + .01\, QE$$

$$\hat{r}_{bl} = 1.0\, r_{eu} - \underset{(-2.9)}{.11} \log EP_w/P + \underset{(2.4)}{.04}\, QE$$

$$\hat{r} = r_0 + 4.0\, D\log M$$

$$\hat{E} = E_0 \frac{P}{P_w}$$

$$\hat{T}_{11} = T_{01} t_1 WL$$

$$t_1 = t_{11} W^{.71}$$

$$\hat{T}_{21} = T_{02} t_2 Pd$$

$$\hat{T}_{22} = T_{03} t_4 WL$$

Notes:

1. A subscript of zero indicates a constant, but no estimates are given since these terms are, in general, under-identified.
2. The figures in brackets are 't-ratios', defined as the ratio of the parameter to its asymptotic standard error. The distribution of the 't-ratio' is asymptotic standard normal.
3. If t-ratios are not given, the relevant parameter values are constrained.
4. The estimation period is from 1959(3) - 1975(4).
5. *RMSPE1* and *RMSE1* denote approximate root mean square percentage error and root mean square error respectively, in terms of the levels of the endogenous variables for a one period simulation over the estimation period.
6. *RMSPE2* and *RMSE2* denote approximate root mean square percentage error and root mean square error respectively, in terms of the levels of the endogenous variables for a dynamic simulation, 1966(3) - 1977(3).
7. These 'goodness of fit' statistics refer to the reduced form equations and not the structural equations above.

VARIABLES USED IN THE MODEL

A	bank advances to private sector
B	bonds held by private non-bank groups
c^*	real cash benefits to persons
C	domestic credit
CTB^*	effective company tax base
d	household expenditure
E	exchange rate ($A/$US)
F	net Australian capital owned by overseas residents
$g_1{}^*$	real government current expenditure
$g_2{}^*$	real government capital expenditure
$g_3{}^*$	real public authorities capital expenditure
h^*	required liquidity ratio of the banking sector
i	real imports of goods and services
I^*	interest payments on government debt
k	proportionate change in business fixed capital
K	real stock of business fixed capital
l	proportionate change in employment
L	employment
M	stock of money (M3)
$MISC^*$	miscellaneous items in the money supply identity
N	labour supply
P	price of output
P_g	price of government consumption expenditure
$P_i{}^*$	Australian import prices ($US)
$P_w{}^*$	world prices ($US)
$P_{wl}{}^*$	price of wool ($US)
P_x	price of exports
QA^*	dummy variable for requests to limit advances, 1961
QDS^*	synthetic variable for US dock strike, 1969
QE^*	synthetic variable for expectations about the exchange rate, 1972-6
QER^*	synthetic variable for timing of exchange rate changes, 1972, 1973, 1974, 1976
$QF_1{}^*$	dummy variable for controls on capital inflow, 1973-4

$QF_2{}^*$	dummy variable for expectations of capital outflow, 1975-6
$Q_1{}^*$	dummy variable for shake-out effect in labour market, 1974-6
$Q_r{}^*$	dummy variable for increases in commercial bill rate, 1974
QS^*	synthetic variable for increases in official interest rates, 1961, 1973
$Q_t{}^*$	time trend starting in 1974(4), zero earlier
QUS^*	dummy variable for devaluation of $US, 1973
r	10 year bond rate
r_{bl}	90 day commercial bill rate
$r_{eu}{}^*$	90 day Eurodollar rate
$r_w{}^*$	10 year US bond rate
R	gold and foreign exchange reserves
s^e	expected sales
sd^*	real statistical discrepancy
t^*	time trend starting in 1959(3)
$t_{11}{}^*$	index of income tax rate schedule
$t_2{}^*$	average rate of tax on expenditure
$t_3{}^*$	average rate of tariffs
$t_4{}^*$	average rate of payroll tax
$t_5{}^*$	company tax rate
T_1	receipts of direct taxes
T_2	receipts of indirect taxes
v	real stock of inventories of goods
$w_A{}^*$	real award wages
W	average weekly earnings
x	real exports of goods and services
$x_w{}^*$	real world exports of goods and services
y	real output (net of depreciation)
Z^*	population of working age
$\lambda_1{}^*$	target rate of growth of real output, value = .012
$\lambda_2{}^*$	target rate of monetary growth, value = .021
$\lambda_3{}^*$	trend rate of technical progress, value = .0045
$\lambda_4{}^*$	trend rate of growth of labour productivity $(\lambda_{3/(1-.3)})$
$\lambda_5{}^*$	trend rate of growth of real award wages, value = .0029
$\lambda_6{}^*$	differential growth rate between sales and stock of inventories of goods, value = -.0011

Notes:

1. Items defined in section II of the above model specification are not variables in their own right, but merely short hand notation for the relevant expressions which are substituted into the model for estimation and simulation. They are thus excluded from this variable listing.

2. The items marked with an asterisk are exogenous to the model.

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DISCUSSION

John Dowling thought that the paper by Dae Sik Kim contained some interesting counter-intuitive results; in particular, stagflation as a consequence of a devaluation or a decrease in the money supply. These responses do not occur as a reaction to high unanticipated inflation as in a Phelps-Friedman-type model, but result from the sensitivity of output and prices to changes in the cost of credit in the informal market. A number of discussants were intrigued by the small impact of an expansionary monetary policy on the price level. This came partly from the short-run effect of borrowing costs on the price level, but as Helliwell pointed out, the more fundamental reason was that the exchange rate is exogenous in the model. An expansionary monetary policy causes a reserve loss which could not be sustained indefinitely; when the exchange rate is ultimately devalued, a significant increase in the price level would follow. Hiroshi Yomo observed that the exogeneity of the wage rate was also a relevant factor in this context. Kim responded that a number of features of the Korean economy have to be borne in mind when interpreting his model and results. In particular, the exchange rate was fixed until 1980 and there has been considerable slack in the labour market. In any case he thought that endogenizing the exchange rate would have little effect on the results.

As regards John Taylor's paper, Hiroshi Yomo emphasized the importance of price expectations and the behaviour of wage settlements. The specification of these processes is crucial to the results, especially the force of the wage-price spiral. Monetary policy might have a much larger impact on price expectations after an extraordinary supply shock than under normal conditions, making econometric analysis of such shocks very difficult. Price expectations might also underlie the apparent positive correlation of the savings rate and monetary expansion. Yomo also considered it important to model the effect of energy prices on potential output growth by explicitly entering energy into the production function.

Other discussants took up the effect of inflation on the savings rate. Longworth said that saving, as defined in the National Accounts, will be correlated with inflation because the real value of financial assets is reduced by inflation and by increased nominal interest rates. Households wanting to preserve the real value of their financial assets must save more, at least as saving is defined under standard national accounting conventions. Helliwell and Keran, citing U.S. experience, noted that inflation could reduce the savings ratio depending on how it is perceived by consumers.

SIMULATED MACROECONOMIC CONSEQUENCES OF ALTERNATIVE PATHS OF ADJUSTMENT OF CANADIAN ENERGY PRICES TO WORLD LEVELS

David E. Rose
Jack G. Selody
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Bank of Canada

This is a revised version of the paper presented at the Conference. Many people have worked on the model used in this paper. In alphabetical order they include, John Armstrong, Tom Bennett, Pierre Cloutier, Louis Fournier, Kevin Lynch, Bruce Montador, John Parker, Andy Rose, and Freida Wong. We have also received valuable comments and other assistance from our colleagues at the Bank of Canada and in particular the Research Department. The authors are responsible for the content of this paper. No responsibility should be attributed to our friends or to the Bank of Canada.

1 INTRODUCTION

In recent years Canadian energy prices have lagged considerably behind their world counterparts. This paper is motivated by questions concerning the properties of alternative adjustment paths towards world price levels. What are the consequences of a relatively faster (slower) approach to target values? Is there any potential advantage, for example, in reducing the costs of transition by delaying the adjustment somewhat, with advanced warning that later increments would be relatively larger (giving economic agents time to plan)? To what extent must Canada suffer a stagflation in the adjustment period? Given that energy is an important input in the production process, what are the likely impacts on factor adjustment paths of varying the profile of the relative factor price changes?

We attempt to answer these questions using a preliminary version of a new macroeconomic model constructed at the Bank of Canada for longer term policy analysis. The model, which we call SAM (Small Annual Model), exists in a preliminary version but we are still tying up the loose ends and are not yet ready for full model simulations. For this paper, we used the supply-side core of SAM in which some portions of the full model are exogenized and replaced with recursive structure and other portions are replaced with simplified simulation rules. More detail on the model is available from the authors on request.

Several aspects of SAM make it particularly useful for these experiments. One case in point is that we have placed great emphasis on long-term relationships (in this paper, we present simulations over a 20-year period). This implies a careful identification of what is fundamentally exogenous and an imposition of consistency on forward-looking expectations.

Output in SAM is produced using three factors of production: capital, labour, and energy. When factor prices are fairly stable, in relative terms, there will tend to be close association of cycles in output and cycles in, for example, labour markets. In such circumstances, it may not be useful to identify energy separately as a factor of production. Rather, energy can be buried in the form of the production technology or aggregated with some other measured factor. When relative prices change as dramatically as they have done, however, such specifications miss a key part of the ensuing economic response. Consequently, many existing econometric models were (and many remain) unable to handle factor substitution in response to energy price shocks. We have found that many of the "problems" in understanding the recent history of labour markets and productivity trends are less puzzling when considered in this light.

While SAM is by no means unique in considering energy as a factor of production, there are some novel features in the way we model choices made by firms. For example, all decisions are forward-looking. Firms base factor demand decisions on expected future sales and on expected future factor prices; exactly how this is done will be described in Section 2. We do not believe that expectations should be made completely consistent with the predictions of the model, in the sense of Muth.[1] However, when decisions are based on future expectations, it is untenable to postulate that local disequilibrium conditions would be expected to prevail forever. All agents in SAM form expectations that are consistent with the steady-state properties of the model.

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[1] J. Muth, "Rational Expectations and the Theory of Price Movements", Econometrica, July 1961.

Local information is important, of course, but agents always look forward with some rough model of the horizon and profile of the move to a steady-state path. Thus in the steady state, expectations are consistent, and away from steady state, expectations are consistent with a move towards a steady state.

Certain steady-state properties are then imposed in the model. For example, the rate of growth of the population and the rate of technical progress are taken to be fundamentally exogenous, and they determine the steady-state real growth rate. Our "consistency" requires the recognition of this property everywhere in the model, including the formation of expectations. We also assume that there is no long-term supply constraint on energy. In particular, we adopt the view that current experience reflects a large relative factor price change, but that in the steady state factor price ratios and real factor prices will be constant.[2] A model in which real energy costs could rise continuously in steady state would be quite different in its long-term properties and in the way decisions would be made, particularly with respect to the role of forward-looking expectations.

To summarize, we shall consider the consequences of a movement in Canadian energy prices towards current world levels using a model in which energy, along with labour and capital, is treated as a factor of production, and in which great care has been taken in the specification of forward-looking decisions which are internally consistent in the steady state.

Section 2 contains detailed information on SAM, focusing on aspects of the model which are important for the simulations to follow. Section 3 describes our experiments from a methodological perspective. Section 4 contains our results. In Section 5 we attempt to summarize and draw conclusions.

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[2] We allocate all gains from technical progress to labour and our statements in the text apply to efficiency-unit real wages or the cost of a unit of labour services.

2 ASPECTS OF SAM

In considering the state of macroeconometric models in late 1979, especially in the light of questions that were arising from energy price changes, it was decided that a new quite different modelling project should be undertaken. It was felt that we needed a tool for medium- to long-term policy analysis -- a model firmly grounded on theory, carefully specified with respect to long-term properties, and relatively small and adaptable to specific needs. Many of those specific needs in the short run revolved around energy, but the goal was more general than merely to expand the catalogue of factors of production. Our philosophy and intentions have been documented in a Bank of Canada technical report.[3]

The "small" of SAM must be interpreted with some care. In the current version there are only 24 stochastic behavioural equations, but these are augmented by well over 100 other equations: accounting identities, definitions, link equations, simulation rules, and equations describing historical trends and fluctuations of series for which expectations are required. Some of these "other" equations are stochastic in the sense that they contain parameters estimated from the data. So SAM is small in its behavioural

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3. Paul R. Masson, David E. Rose and Jack G. Selody, "Building a Small Macro-Model for Simulation: Some Issues", Bank of Canada Technical Report 22, November 1980.

core and small compared to many other macroeconometric models, but does not fall into the increasingly popular genre of "handful-of-equations" models.

The choice-theoretic foundations for SAM are provided by models of decisions in continuous time, forward-looking to the infinite future, but limited for practical purposes by discounting and other similar weighting schemes. The model is "annual" for estimation and simulation, and we have, wherever possible, analytically derived from the continuous time formulation the functional specification and the appropriate definitions of the data. For example, we typically integrate a continuous-time equation over an annual interval. A rate of flow in continuous time then becomes the flow over the year, a stock (or price or anything with similar point-in-time definition) becomes the average stock over the year, a derivative of a stock becomes the change in the stock from the beginning to the end of the year, and so on. We have been influenced by the work of Bergstrom and Wymer,[4] and P.D. Jonson and his colleagues at the Reserve Bank of Australia in the RBA models.[5]

SAM follows in the steps of its RDX (and many other) predecessors in that it specifies a production function for private output and identifies the demands of different sectors for that output. The model differs from RDX in that we exclude energy production from our modelled private sector and include agricultural and related production. Output for our non-energy private sector is defined to be gross output, corresponding to payments to all factors including energy. As such, non-energy sector output is defined to include its energy use in addition to the usual value added by capital and labour. Output also includes a service flow imputed to the stock of residential housing, and this stock is included in the capital stock that enters in the production function. Energy is defined in its narrowest sense, that is, primary energy, and excludes conversion or transformation. All domestic usage of primary energy appears as an input to production. By defining energy narrowly, and by including housing services explicitly in the production function, we avoid modelling household demand for energy separately from industrial demand. Transformation of energy to its final form, and use of primary energy for domestic heating and lighting, appear together in the composite output good.

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[4] Relevant references include: A.R. Bergstrom (ed.), Statistical Inference in Continuous Time Econometric Models, Amsterdam: North-Holland, 1976 and especially the paper of Bergstrom and Wymer; and A. Swoboda, M. Mussa, and C.R. Wymer (eds.), Macroeconomic Policy and Adjustment in Open Economies, Proceedings, SSRC Conference, Ware, England, 1978, and especially the paper by Wymer.

[5] See, for example, Conference on Applied Economic Research, Reserve Bank of Australia, December 1977.

Decisions are forward-looking. "Normal" sales are defined to be an exponentially declining forward-weighted average of expected sales at trend value, with limit consistency on the expectations as described earlier. "At trend value" means simply that firms abstract from current fluctuations in defining normal. "Desired" output is defined to be normal sales plus any desired changes in inventory stocks. On a steady-state path, inventories would be at the desired level and desired output would equal normal sales which, owing to growth and the forward average, are larger than actual current sales.

"Desired" factor usage is defined from static cost minimization conditional on the presumed nested CES technology, desired output, and "normal" factor prices.

Normal factor prices, like normal sales, are forward averages of expected factor prices at trend values. Factor prices appear as ratios, of course, and we can consider the ratios in real or in nominal form, the common deflators cancelling. We chose to work in real form and expectations were formulated about real factor prices directly.

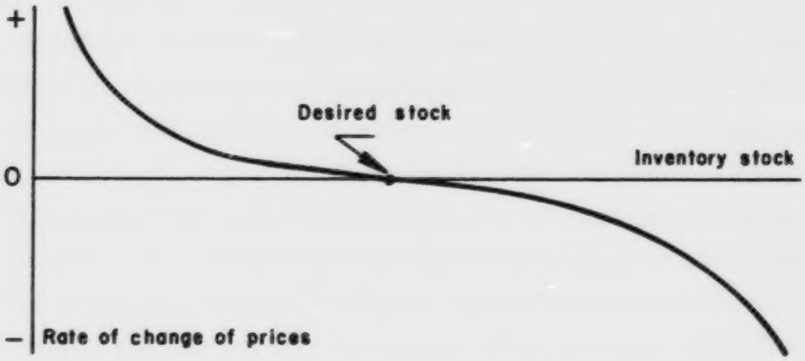
As noted above, domestic production is treated as if it were composed of two goods, energy and non-energy. Energy production, exports and prices are for the present exogenous, but domestic use and imports of energy are endogenous. On the demand side, the domestic non-energy good is assumed to be an imperfect substitute for foreign goods; both can serve for either consumption or investment.

Consider now the adjustment to equilibrium in the product market. Movements in inventories have an important role to play in this process, and we have chosen to model the level of inventories and price-setting as being closely linked. Inventories are held to permit some buffering of unexpected fluctuations in demand. When inventories are close to desired levels, actual inventories will respond relatively passively to small discrepancies between supply and demand, with price relatively unaffected. However, a substantial divergence of actual from desired stocks will bring about a price response in a non-linear form, roughly as illustrated in Figure 1. We hasten to add that other things influence the rate of change of price; we are speaking only of the form of the "gap" measure we shall use.

In a similar fashion, demand and supply can differ in the labour market. The real wage may deviate from a market clearing value owing to expectations errors and wage rigidities. We postulate an expectations-augmented Phillips' curve where the gap between the actual unemployment rate and the natural or equilibrium rate[6] has a non-linear effect on the rate of change of wages similar to that shown in Figure 1.

Figure I

The Response of Inflation to an Inventory Gap



Our analysis of desired inventories is standard. Firms wish to hold inventories (to buffer demand and supply fluctuations) in proportion to normal sales, with the proportion depending on the real cost of inventory finance (which we assume to be proportional to the expected real return on treasury bills). This cost variable has proven to be statistically insignificant in estimation, but it has an intuitively plausible (negative) sign and we have retained it.[7]

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[6] For estimation we take our natural rate measure from the Bank of Canada's RDXF model. In that model, a variable is generated which, although not put forward as "the" natural rate, is close enough for our purposes.

[7] Details of these and other estimation results affecting this paper are available on request.

Our production technology is a nested CES function. Capital and energy are nested in an internal CES bundle, with this bundle itself related to labour in another CES structure. Technical change is "Harrod-neutral" by assumption -- embodied only in labour. Estimates of the technical change parameters are taken from the production technology and imposed elsewhere. The actual technology specified is as follows:

```
UGPC = AF10*((AF05*AF08*((AF04*(KC**AF06)
        +(1-AF04)*(ENC**AF06))**(AF07/AF06))
        +(1-AF05)*((PRODT*LC)**AF07))**(1/AF07)
```

where UGPC is output; KC, L, and ENC the inputs of capital, labour, and energy, respectively; and PRODT is productivity or technical change. AF08 and AF10 are scale parameters. They depend on the units chosen for measurement. AF04 and AF05 are "share" parameters. Inside the capital-energy bundle AF04 describes the weight applied to capital, and (1-AF04) the weight to energy. Similarly AF05 and (1-AF05) are weights applied to the "bundle" and labour respectively in efficiency units. AF07 and AF06, the exponents, determine the substitutability of factors. KC, ENC, and LC are the non-energy sector usages of capital, energy, and labour, respectively.

The Hicks-Allen partial elasticity of substitution (output and other factor prices fixed) between labour and either capital or energy is given by (1/(1-AF07)),[8] whereas the substitutability of capital for energy can be written as

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[8] See, for example, K. Sato, "A Two-Level Constant-Elasticity-of-Substitution Production Function". *Review of Economic Studies*, April 1967.

$$S_{KE} = 1/(1-AF07) + (1/(1-AF06) - 1/(1-AF07))/ShKE$$

where ShKE is the expenditure share of the KE bundle. Note that the Hicks-Allen partial elasticity of substitution of capital for energy is constant only so long as the expenditure share stays constant.

Sato suggests that more highly substitutable factors (in the direct partial elasticity of substitution sense) be grouped together in a bundle. He offers no reason (aside from "introspection") and admits that the function is mathematically well behaved the other way around. However, it is clear that his argument comes from an "aggregation" perspective. He feels that since, in the limit, very close substitutes are indistinguishable and may be aggregated, close substitutes belong together in a "bundle". However, between "bundles", the partial elasticity of substitution is necessarily positive with this form (i.e., bundles are substitutes). Only within bundles can complementarity emerge. Thus bundles should be defined by associating the most likely complements (or weak substitutes). We felt that at least in the short run, capital and energy are not very substitutable, given that energy requirements for a given vintage of capital are relatively fixed. Our current best estimates are consistent with this view, but we hasten to add that the estimates will depend on the bundling chosen and we have not investigated alternative structures. Our bundling is identical to that chosen by Helliwell and McRae.[9]

Desired factor usages are derived using static cost minimization given the CES technology, to be particular functions of desired output and the ratios of normal factor prices.[10] Actual factor usages can deviate from desired usages owing to costs of adjustment. We formulated our dynamics with the following properties.[11] First, we have attempted to provide a framework of simultaneous adjustment of all three factors. Second, economic variables affect the adjustment process so that speeds of adjustment are not exogenous constants. The structures are specified such that actual proportional change is equal to desired change, modified by a series of terms which vanish in steady state. In each equation there is an output gap term, reflecting proportional deviation of the actual from the desired output.[12] This term is designed to show the immediate impact of a demand shock on factor use. Next we include for each factor the deviation of the ratio of actual to desired usage from the steady-state ratio. This term ensures that the steady-state equilibrium is approached over time. Next we include the expected course of relative factor prices over the adjustment horizon. For example, if wages are expected to fall relative to energy costs, relatively more labour may be employed in anticipation of the relative price change. The relative price terms are written as proportional deviation of present value price ratios from current price ratios. Note that this relative price effect is on the adjustment dynamics and is additional to the influence of relative factor prices on desired factor usages.

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[9] John F. Helliwell and Robert N. McRae. "Output, Potential Output, and Factor Demands in an Aggregate Open Economy Model with Energy and Capital Bundled Together", 1981.

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[10] A derivation is available in B. Montador and J. Armstrong, "Deriving Factor Demand Equations", Bank of Canada, RM-81-110.

[11] In modelling factor adjustments we began with simple stochastic optimal control problems with quadratic costs of adjustment relative to the equilibrium path, as for example, in T.J. Sargent, "Estimation of Dynamic Labor Demand Schedules under Rational Expectations", Journal of Political Economy, 1978. However, mathematical tractability forced restrictions on the generality of the adjustment processes which we found implausible, so we abandoned the attempt to use explicit control foundations for our dynamics. We do, however, retain some of the influences suggested by our formal models.

[12] Strictly speaking this statement is incorrect, since desired output reflects forward-looking behaviour and, owing to real growth, is larger than actual output at any point on a steady-state path. However, we simply rescale by the known proportionality factor and the statement in the text is essentially correct.

The formal estimation problem is formidable. The production technology plus the factor equations represent a highly non-linear system with 23 free parameters. There are very complex cross-equation restrictions. For these experiments we used estimates of the technology plus imposed-coefficient factor dynamics. The technology was estimated using annual data from 1957 to 1979 with a directed grid-search algorithm. The function fits reasonably well (the R^2 is .998) and does not have severe residual autocorrelation (the D.W. statistic is 1.42). We cannot report confidence intervals for individual parameters, but we can give some indication as to how well parameters are determined. There are two multi-dimension "valleys", one with fairly steep sides, and one fairly flat. The valley floors are long. As such, the parameters are not well determined globally, as large numbers of particular combinations fit roughly equally well. However, the indeterminacy is only in particular "directions". The steep valley dominates the shallow valley so that tests which require movement "sideways" from the valley floor produce strong rejections. For example, we shall report below that capital and energy are substitutes, but with an elasticity which is relatively low. It seems that for whatever point you pick, at least in the steep valley, the restriction that moves the elasticity estimate to the crossover point (for complementarity) is strongly rejected.

Our estimate of the Hicks-Allen partial elasticity of substitution of labour for energy or capital is .893 which is significantly different from unity (i.e., Cobb-Douglas for the outer CES). For energy and capital we find an elasticity of substitution (setting the share of the bundle to its sample mean) of .293. Our finding that energy and capital are substitutes is noteworthy, especially given its apparent robustness.

The elasticities of the factor demands with respect to each of the individual real normal factor prices (output and other prices held fixed) are reported in Table 1. Note that energy is the most responsive of any of the factors to a change in its own price.

TABLE 1

ELASTICITIES, EVALUATED AS MEAN OVER THE SAMPLE

	WREN	PENRN	CCRN
LC	-.27	.08	.19
ENC	.62	-.68	.06
KC	.62	.02	-.65

Although we have imposed coefficients on the dynamics, we did use estimation to guide us in verifying intuition as to what should adjust relatively quickly and what should adjust relatively slowly. We set the "own gap" coefficients to relatively (though not absolutely) large values, and we made labour the most variable factor in the short run. We feel that the dynamics are reasonable enough to make the experiments interesting. The simple correlations between the fitted values using our imposed coefficients and the actual data over the sample are .57, .71 and .37 for labour, capital and energy, respectively. However, the mean errors are far from zero and there is considerable room for improvement with a systems estimator.

As regards our treatment of trends, fluctuations, and the forward-looking variables such as normal and present-value prices, for brevity we shall discuss only the labour market variables. Real wages are presumed to have local trends from two sources: productivity and other sources of a disequilibrium nature. We identify two sources of breaks in these trends: the effect of the post-World War II baby boom moving through the early stages of its life cycle, and the effect of a major disequilibrium episode consequent to the large changes of relative factor prices in the 1970s and early 1980s. In identifying such changes of trend we do not consider the various endogenous variables seriatim. Rather, we associate kinks with structural changes affecting the fundamentally exogenous variables. These changes are applied consistently throughout the model. We posit that agents respond differently to trends and fluctuations. Of course, the judgement is somewhat arbitrary as to what is a longer-lived fluctuation around a stable trend and what is a sequence of local trends. We cannot date precisely where kinks occur and there may be other explanations as to why they occur, but we do not find useful a trend model that says, for example, there is only a half cycle in the data. Therefore we attempt to say something systematic about when kinks occur. When changes occur agents are not presumed to know the new "truth" immediately. Rather, a learning process takes place such that expected trends converge on actual trends exponentially. The 1963 kink is learned a bit faster than the one in 1973, the argument being that demographic influences were somewhat easier to understand than the factor price shocks of the 1970s. The parameters of the learning processes are imposed, not estimated. It does not appear possible to identify such processes empirically. In any case the net effect of actual kinks plus learning is a transition from one trend value to another.

One way in which the distinction between perceived trends and fluctuations plays a role in SAM is in the definition of normal variables. Normal variables are defined to be exponentially weighted forward averages of expected trend values of variables. In each case an a priori choice is made as to what the effective horizon of the average should be. By convention we refer to the horizon as T if by T years into the future, 95 per cent of the weight in the exponential function has been applied. For decisions by firms we choose a horizon of six years.

There is more to normal variables, however. A model cannot be consistent or attain equilibrium in the full sense of the word unless all expectations are fulfilled at least in terms of trends. We would go farther and say that while continuous Muth-consistency of expectations may not represent a sensible restriction on a model, such consistency in the steady state is essential. We impose it on expectations. Simply put, agents have a view of the steady state, and they use a model of how local trends go to steady-state trends in forming their forward-looking expectations. For level variables such as real wages, we use a step function approach to steady-state growth rates. Local trends are used for a certain notional distance into the future, then (in three steps) they are reduced to the steady-state value. For example, in a steady state, any real wage trends must be productivity trends. There can be no local efficiency wage trends. So the normal efficiency real wage is defined using a forward average which takes the local trend to zero in three steps. The horizon is chosen arbitrarily. For these experiments we use the local trend for 1.67 years, two thirds of the local trend for another 2.5 years and one third of the local trend for an additional 3.33 years. Thereafter, real wage trends are constrained, in the expectations, to be equal to productivity trends.

Present-value prices differ from normal prices in two ways. First, they are not weighted averages -- the integral of the weighting function cannot be 1.0, but greater than 1.0 for the integral to exist. Second, the expectations are not simply trend values, they utilize a fluctuations model estimated in conjunction with the trends model. In principle, the model of fluctuations about the trend can be quite complex. For the time being we have restricted our models to first-order autoregressive processes. The estimated fluctuations structure is included in the solution of the forward integral. In such solutions, Muth-consistency of the steady state is imposed in the same way as for normal values.

Finally let us consider wage and price dynamics. The rate of change of wages is given by:

$$\begin{aligned} \mathrm{DNW} = {} & \mathrm{DNWRT} + .116*\mathrm{DNPCE2} + .884\mathrm{DNPE2} \\ & - .075*(.362*\ \mathrm{LOG}(\mathrm{RNU}/\mathrm{RNAT}) \\ & + .638*(\mathrm{EXP}(.567*\mathrm{RNU}/\mathrm{RNAT}) \\ & - \mathrm{EXP}(.567))) \end{aligned}$$

The first term is simply the trend rate of increase of real wages (productivity plus other local trends). The next two terms represent the effect of inflation expectations. The first of these (DNPCE2) represents household expectations of consumption bundle inflation. This recognizes that there are agents on the supply side of the labour market and gives import prices some role in short-term wage and price dynamics. The second (DNPE2) represents firms' expectations of domestic product price inflation. In the short run these rates of inflation can differ, but in the long run they must come together. In steady state there is a unit coefficient on the expected rate of inflation. This restriction is imposed; the "split" is estimated. The figure 2 at the end stands for a two-year horizon in the sense discussed above. The expectations are made consistent in the limit and reflect an imposed perception that the authorities plan to reduce the rate of inflation to zero in a steady state. The gap parameter (-.075) comes from estimation, but the other coefficients internal to the functional form for the gap are imposed. The parameter reported as .567 is imposed to make the gap measure symmetric about the natural rate of unemployment, RNAT, in the sense that a small movement in the actual rate, RNU, puts the same relative pressure on wages, whether that pressure is upwards or downwards. This restriction was not tested. The parameter shown as .362 is imposed to make the second derivative of the gap (with respect to the ratio) zero when RNU=RNAT. This restriction was tested and decidedly not rejected by the data. The resulting gap function (see Figure 1, above) is thus symmetric to second order in the neighbourhood of RNAT. It is admittedly difficult, given restricted historical experience, to tell what the curvature of such functions looks like far away from sample means, but we are willing to defend the notion that at some point the function becomes non-linear. Clearly this issue is very important for the simulation properties of a model.

```
DNP = DRINDT/(1+RINDT) + .825*(DNW-DNWRT)
      + .002*DNCC + .173*DNPEN - .04*(.362*LOG(INVC/INVCD)
      + .638*(EXP(.567*INVC/INVCD) - EXP(.567)))
```

This equation, which specifies the rate of change of the domestic price is similar, in that the same type of gap functional form is used (with INVC/INVCD replacing RNU/RNAT). It too is estimated with the curvature of the gap function imposed. In addition to the gap, the rate of change of net indirect taxes appears with a unit coefficient as do the rates of change of nominal capital cost, energy price and money wage adjusted for trend real increases. Note that a homogeneity restriction has been imposed on the factor cost terms.

3 THE MODEL FOR SIMULATION AND THE EXPERIMENTS

As noted previously, we shall not be reporting "full model" simulations. Included are the supply side of the output market (production technology and factor demands), the wage and price dynamics, relevant variables affected by expectations formation and all necessary technical relations. To maintain the "macro" nature of the experiments, we use simulation rules for some variables, wherever possible specifying these rules to be consistent in steady state with a more complete version of SAM. For example, we replace a series of equations which guarantee that purchasing-power parity will hold in steady state with a simple partial adjustment model.

Financial variables (including the user cost of capital) and most fiscal policy variables are exogenous. We assume that when inflation varies in simulation it is accompanied by an equal variation in nominal interest rates, keeping real rates and the user cost of capital constant. We assume further that the money supply is accommodating, responding in the short run to validate such a scenario. In the longer term, however, the money stock approaches a growth path consistent with zero inflation. Agents know this goal of the authorities and form expectations consistent with it. The shocks are all relative factor price changes and perceived to be so with no permanent implications for the rate of inflation, although the price level can be permanently affected. On the other hand, we recognize throughout the model that local trends can exist for some time. Agents recognize this and modify their view of local trends as simulation yields varying actual rates of inflation. However, expected rates of inflation are forward-looking and, just as for factor prices, consistency of the steady state is imposed. Expectations play a special role in the simulations for this paper because it is through expectations that we get a zero inflation steady state. We force the weight given to steady-state properties to rise as the simulation proceeds, so eventually both actual and expected inflation equal zero.

Lucas[13] has emphasized that simulations can be very misleading if the model structure is not flexible enough to respond to changes in policy regime. We cannot pretend to have a fully flexible structure, but we can claim to have made some important steps in meeting Lucas' criticism. First, as noted above, agents' actions are consistent with the actual behaviour of policy variables, at least in the steady state. Second, while estimation trends are taken as exogenous (though

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13. R.E. Lucas Jr., "Econometric Policy Evaluation: A Critique." In the Phillips Curve and Labour Markets, K. Brunner and A.H. Meltzer (eds.), Carnegie-Rochester Conference Series on Public Policy, vol. 1, 1976.

with kinks plus learning transitions), in simulation, expectations are further endogenized by defining perceived local trends which converge with learning to the actual outcome in simulation. This further endogenization of expectations in simulation is applied to "levels" variables, such as normal factor prices, as well. In most cases the functional form specified is unchanged from estimation. But the "input" variables, such as perceived levels and rates of growth on local trend lines, are endogenized.

Consider now the specific experiments. We estimated a sample ending in 1979 and simulated from 1980 to 1999. World prices, including energy, were taken as exogenous. In Figure 2 the assumed real world energy price is plotted. As is evident we have a large real increase in 1981 (about 8.5 per cent) followed by a 2.2 per cent real decline in 1982. Thereafter, real increases continue but at rates which after rising briefly to a maximum 1.56 per cent per annum decline continuously towards zero. To 1985 the series reflects what was considered reasonable by colleagues specializing in the area. Thereafter, we imposed the slow decline towards zero.

Our experiments presume that Canada will adapt in steady state to the world price of oil such that the U.S. dollar-equivalent of our price will eventually equal the world price. Our measure of energy contains more than oil, but we calculate the necessary adjustment of our energy price on the assumption that the domestic prices of other sources of energy move with the price of oil, keeping the same rough proportional relationships.[14] As a result, our domestic

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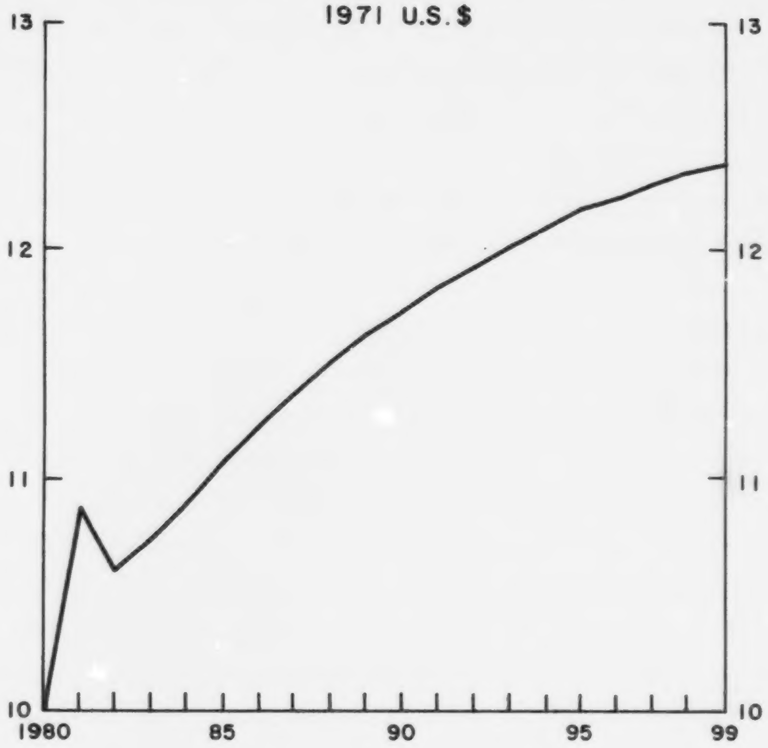
[14] We could also have assumed that the quantity ratios stay the same with the same result for the over-all index, but we feel that the price assumption is more reasonable.

Figure 2

Assumed World Energy Price Index

1971 U.S.$



energy price is presumed to move in proportion to the domestic oil price. This overstates the necessary total increase somewhat, but is adequate for the experiments we wish to perform.[15] As of mid-1979, we would have had roughly to double our energy price at the input-to-the-production-process

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15. Simulations performed by John Helliwell using his MACE model with endogenous response by energy type, suggest that we may overstate the price adjustment necessary by up to 20 per cent.

state to get parity with the then world equivalent.

We assume the domestic energy price expressed in U.S. dollars moves towards the world price. Thus, since we adjust to a purchasing-power-parity exchange rate, one does not go far wrong in thinking of our domestic price path as fixed in real terms: the postulated paths cannot be eroded by inflation.

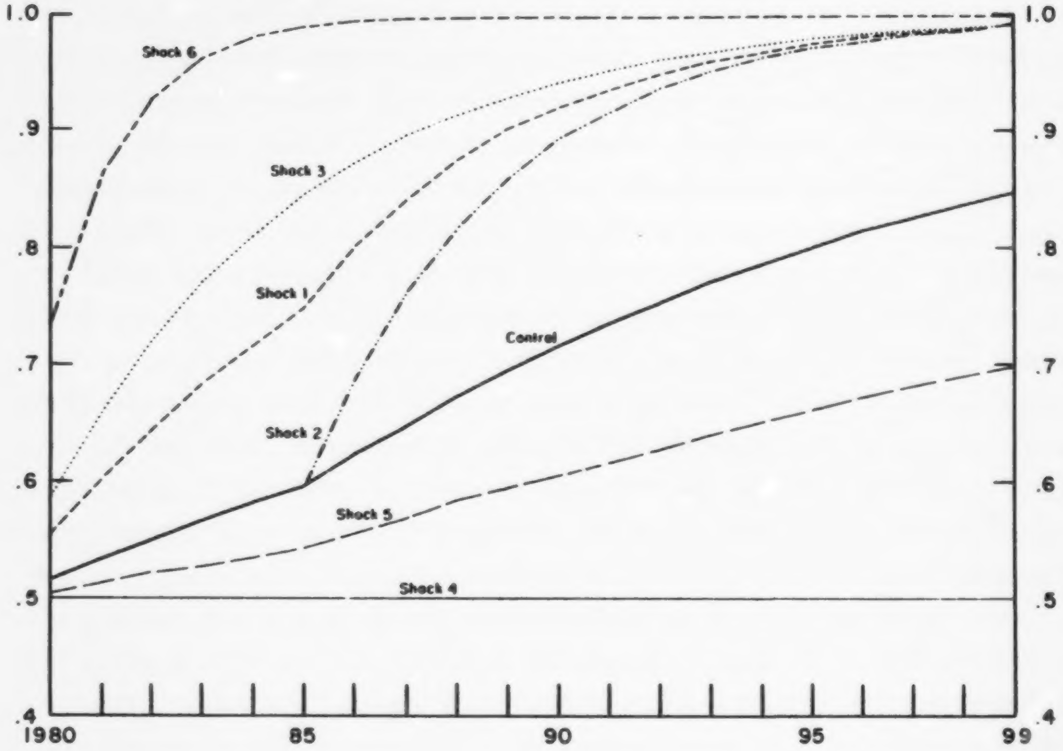
Figure 3 shows the characteristics of our control and shock paths of domestic energy prices plotted as a proportion of the (changing) world price. Our price moves with the world price adjusted for the extra closing of the gap as shown.

In control, we go to 85 per cent of the world oil price by 1999. We go relatively slowly up to 1985 and then accelerate the rate of approach. In shock 1 we reach 75 per cent of the world price by 1985, and continue (again at a higher rate) to 99 per cent of the world price by 1999. Shock 3 represents a constant rate of adjustment (faster than shock 1 before 1985, slower after 1985) which reaches the same end point in 1999. Shock 2 was included to show the impact of delaying the adjustment, but ending up at the same place by 1999. We shall also use this shock to perform a "perfect foresight" experiment where we give agents prior knowledge that a rapid increase is coming, starting at some point in the future. In general, while agents form expectations with limit consistency they do not have knowledge of ex post adjustment paths.

Shock 4 is a "do-nothing" shock included to help us identify the importance of asymmetries and non-linearities in our model. Shock 5 is a less drastic version of a below-control policy: we reach 70 per cent of the world price by 1999. Shock 6 allows us to see what happens under extreme circumstances: we attain over 90 per cent of the world price by 1982 and are virtually at the world price by 1985. Shock 6

Figure 3

Ratio of Canadian Oil Prices to World Oil Prices: Alternative Scenarios



proved very useful in showing us certain properties of the model.

The shocks are considered in the light of various assumptions about model structure. First we specify a basic model and consider the effects of varying the energy price scenario. In these experiments we specify two sources of demand-side feedback. In the inventories equation we add a term reflecting the ratio of our output price to the domestic value of the world price. A similar term is added to the expected sales equation. We think of the latter as reflecting a response to anticipated demand-side feedback, while the former captures directly perceived effects through inventories. When higher domestic prices are generated, inventories build up and expected sales fall, ceteris paribus, both leading to lower desired output and desired factor use. These effects disappear in steady state because of the purchasing-power-parity restriction. We are not suggesting that this represents a realistic model of a terms-of-trade effect or that a terms-of-trade effect is the only mechanism whereby demand-side feedback could occur. Our intention is simply to provide a more macro perspective for our experiments. The large relative factor price changes generate strong signals for substitution towards labour. We want to provide some idea as to whether this substitution effect could be offset in the short run by the scale effects of a reduction in output growth.[16]

We then perform some experiments to look at a type of "vintage" restriction. In these we reduce the substitutability of capital and energy to zero as the experiment starts and let it rise towards the estimated value roughly linearly over the simulation period. Although not a full vintage analysis this does provide a restriction that capital and energy can only be used in (roughly) fixed proportions in the first periods of simulation where the largest relative price shocks occur. The comparison is presented using shock 3.

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[16] We have removed the distinction between basic and alternative models made in the version presented at Vancouver.

Next are what we call horizon experiments. There are two of these. First, working only with shock 6, we reduce the horizon assumed by the firms in their expectations concerning the approach to the steady state. In control, firms approximate the path to steady-state growth rates with the previously described step function. They use the presumed steady-state rate for dates ten years ahead and beyond. A "Lucas-type" criticism can be made if we hold this horizon fixed while varying the actual profile of the adjustment process, especially if we want the authorities' plans to have been "announced". Using shock 6 we shorten this horizon to four years. Second, we go much further and try at least to approximate a perfect foresight solution. This we do with shock 2 so that we can add the extra question of the importance of prior information. Here we change the functional form which determines, for example, the normal energy price such that at each point in time the firms expect a profile very similar to that in shock 2. In addition we decrease the rate at which the future is discounted, on the argument that one reason for limiting the planning horizon (and raising the discount rate) is uncertainty about the more distant future. So, when giving more information we also give more certainty and assume that firms would as a result look further into the future in making their plans. Notice that we limit the perfect foresight to energy prices. We do not give the firms knowledge of the resulting variation in other real factor prices and so on. Thus we introduce a potentially important asymmetry into the information set.

One final point needs to be made before we move on to the results. In SAM the labour supply decision is endogenous. This link is not employed for these experiments. In control, we set unemployment to the natural rate and solve for the required participation rate; otherwise, this participation rate is taken as given. Thus, all employment variation reflects firms' factor demands. The result is a participation rate which rises to about 74 per cent in 1999 from its 1979 starting value of 64 per cent.

4 SIMULATION RESULTS

We begin with the basic model and a comparison of the results for various shocks. Solutions for a subset of the endogenous variables are plotted in Figures 4 to 11. To avoid clutter we omit shocks 2 and 3 from these first charts. When considering these results it is well to bear in mind that the exogenous world real energy price goes through a dramatic cycle from 1980 to 1982, rising sharply and then actually falling before beginning a more orderly rise. As such, some of the cyclical variation evident in the first years of simulation is due to an exogenous cycle.

First, consider energy usage. The increase in the relative price of energy has a powerful effect. Even though energy use is growing at roughly normal rates by the end of the simulations, the level of use is lower than in 1980 even by 1999 for all but the "no change" shock 4. The extent of the short-run decline with shock 6 is perhaps hard to believe. From 1980 levels, energy use is cut by more than half over three years. The contrast of shock 6 and shock 1 results illustrates clearly the non-linearity of SAM. Evidently we get non-linear response as the size of shocks is increased and this leads to more overshooting and cyclical response. Some would undoubtedly argue that these results show the need for a vintage model in which energy use cannot be cut so drastically in the short run owing to technological

Figure 4

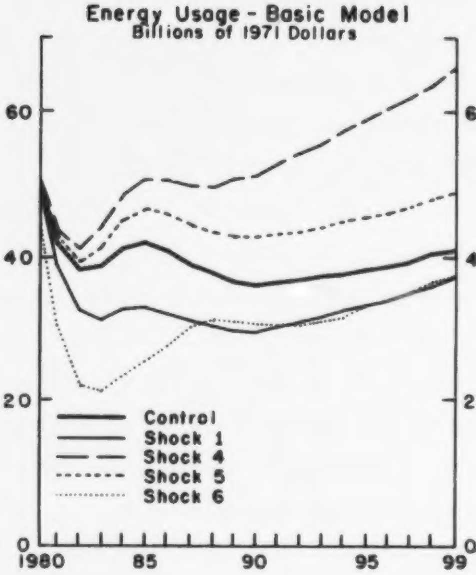


Figure 5

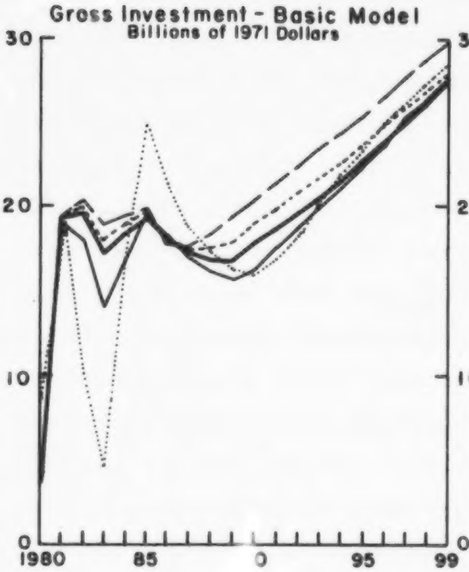


Figure 6

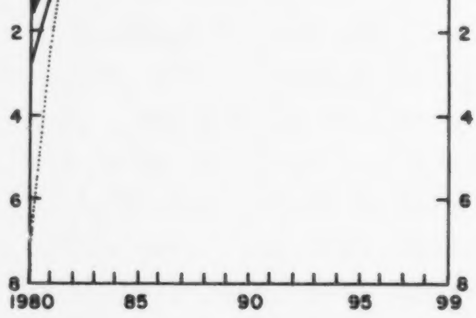
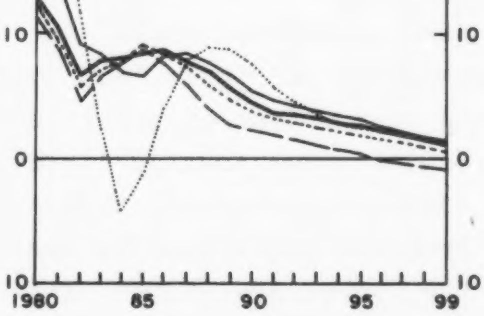


Figure 7



rigidities. While we agree that the shock 6 response is excessive, it is not necessary to go to a formal vintage framework to remove the excesses. We shall show below that some reasonable modifications to the structure used here can go a long way towards removing the extreme cycles. But there is a more fundamental point in that actual growth equals desired growth modified by a series of gap terms. This may be fine for demand shocks or small relative factor price changes, but not for large relative factor price changes. A model that recognized that the most important adjustment costs arise in moving from one level path to another would not permit the desired level shift to feed through the desired rate-of-change term. This will be recognized in future versions of SAM and we have already seen that such a change can remove the unpalatable extreme short-run responses.

Figure 9 shows the extremely large changes of relative factor prices considered. In what follows we shall consider the shocks that take energy prices above control. Clearly, there are enormous incentives to shift towards labour and this shows up as an initial and an eventual decline in unemployment below control. However, there is overshooting in the labour market. The rise in output prices is not fully anticipated and despite very strong excess demand pressures in the labour market, real wages fall initially and take a few years to catch up. Labour becomes cheaper relative to capital for a time, retarding investment spending. The demand feedback shows up in Figure 10. In the first few periods the decline in real output growth is not sufficient to offset the substitution towards labour. Eventually, however, this effect dominates and unemployment rises briefly above control, dropping below control again as output recovers. For shock 6 the cycles are large. This shock told us a great deal about

Figure 8

Purchasing-Power Parity Exchange Rate - Basic Model

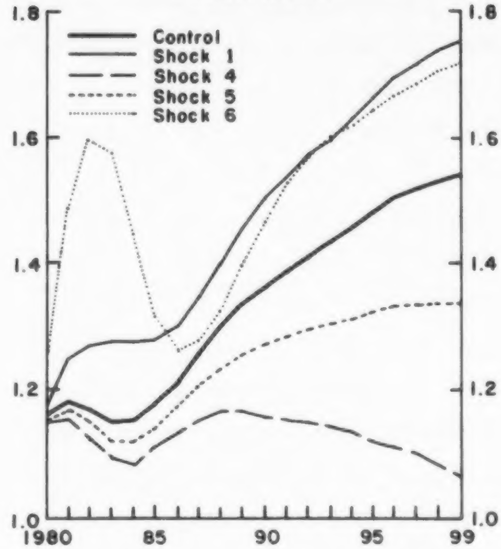


Figure 9

Wage/Energy Price - Basic Model

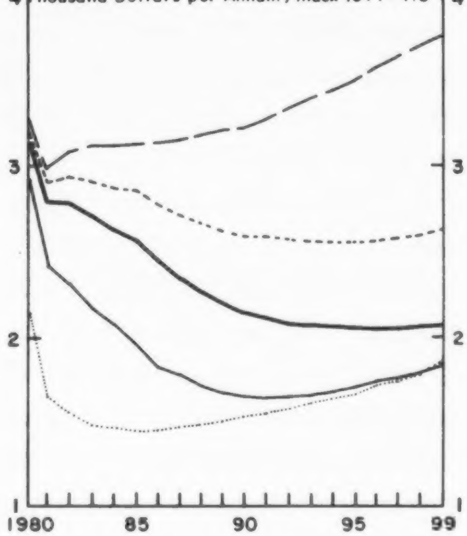


Figure 10

Domestic Output Growth - Basic Model

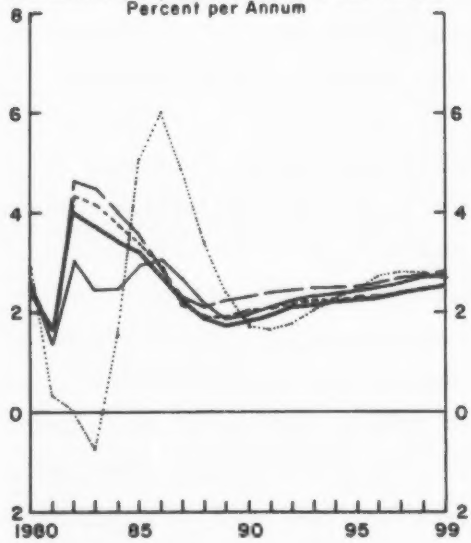
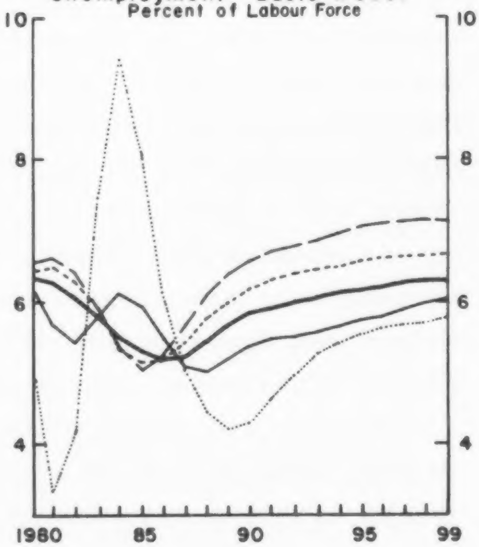


Figure 11

Unemployment - Basic Model



the model, and the results are interesting, but the remarks in the previous paragraph apply and we would not want to posit such results as reasonable descriptions of likely real-world responses. The energy price increases have a direct short-run effect on product price inflation as the costs are passed through the system -- we have more to say about inflation below.

In Figures 12 to 19 we plot the shock 3 results for the basic model and for the vintage model. Clearly the vintage restriction will keep energy use higher than in the basic model. We see from Figure 12 that this effect is quite long-lived. The levels, which will eventually come together, are still markedly different in 1999. The restriction also changes investment. In the short run the desired substitution towards capital is cut off. Indeed we generate a perverse result in the first period with a negative gross investment. Eventually, of course, vintage investment is higher as the capital adjustment takes place. In labour markets there is even more pressure to substitute towards labour. Real wage inflation is higher, investment spending is lower, and inflation is higher leading to stronger negative feedback from demand; yet, despite all of this the substitution effect dominates and unemployment initially falls. Inflation is higher throughout, except for a brief period in the mid-1980s. At this point it is perhaps wise to remind the reader of our essentially passive money assumption. World inflation is exogenous and assumed to be falling towards zero. Our endogenous domestic inflation, through the purchasing-power-parity restriction, has a direct impact on the exchange rate.

The horizon experiments with shock 6 represent a response to the Lucas criticism with respect to the horizon over which agents expect a return to steady state. Clearly the horizon

Figure 12
Energy Usage - Shock 3 - Two Models
Billions of 1971 Dollars

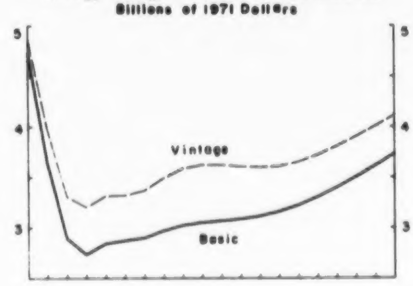


Figure 13
Gross Investment - Shock 3 - Two Models
Billions of 1971 Dollars

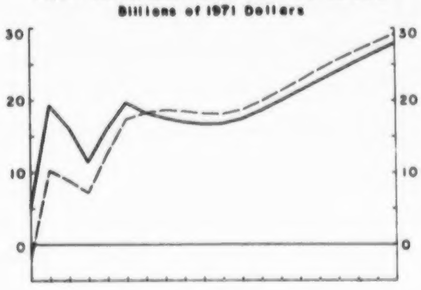


Figure 14
Real Wage Inflation - Shock 3 - Two Models
Percent per Annum

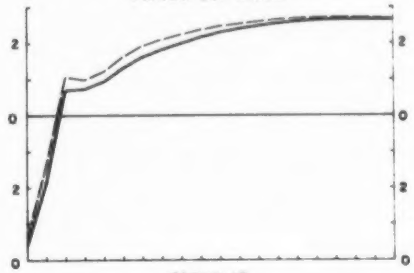


Figure 15
Output Price Inflation - Shock 3 - Two Models
Percent per Annum

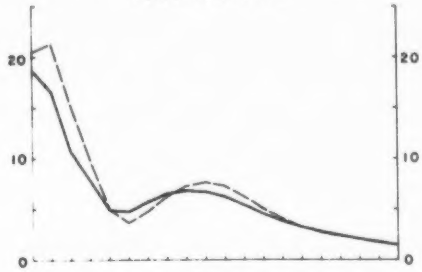


Figure 16
Purchasing-Power Parity Exchange Rate - Shock 3 - Two Models
Canadian Dollars per U.S. Dollar

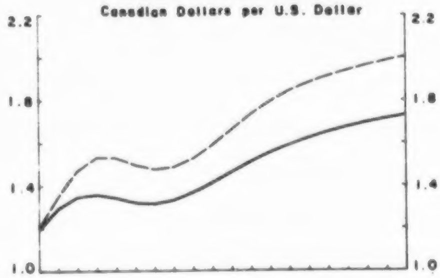


Figure 17
Wage/Energy Price - Shock 3 - Two Models
Thousand Dollars per Annum/Index 1971 = 1.0

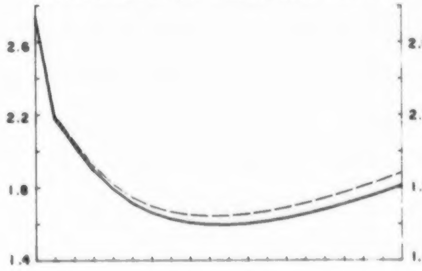


Figure 18
Rate of Growth of Output - Shock 3 - Two Models
Percent per Annum

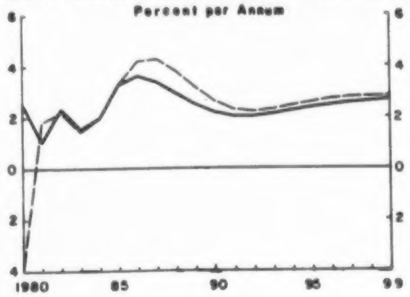
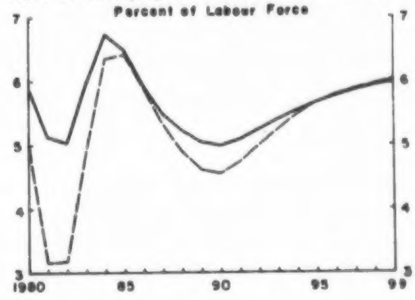


Figure 19
Rate of Unemployment - Shock 3 - Two Models
Percent of Labour Force



parameter for energy price expectations should be shorter, the faster the approach to world prices. We found that this did not matter much for shocks 1 and 3, but it mattered quite a bit for the extreme shock 6.[17] Essentially, the extreme initial cycles are damped, often dramatically, as a glance over Figures 20 to 27 will show. Energy usage does not decline quite so much in the initial downswing though there is still some overshooting. The most marked change is in the unemployment rate where the substantial smoothing gives quite a new flavour to the shock 6 results. For example, the initial downswing stops at 5.5 per cent instead of the 3.3 per cent with the basic shock 6. The initial fall in output growth is of a similar order of magnitude, but it comes sooner and is not so long-lasting at extreme values. Consequently, the boom that follows is less spectacular. One reason for this difference is that inflation does not rise much initially, so expectations go less wrong and real wages do not fall so much. Thus there is less short-run incentive for firms to produce more with the cheaper labour. It is interesting that the model keeps the relative price of labour to energy virtually unchanged despite quite dramatic changes elsewhere. In summary, it is clear that responding to the Lucas criticism by respecifying the way expectations are formed (here, by shortening the assumed horizon when the actual horizon is shortened) has an important impact on the results, removing much of the extremes of cyclical response.

Consider now, using Figures 28 to 35, the second part of the horizon experiments, where we use shock 2 to delay the

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17. Readers of the first version of this paper will recall that we reported the horizon results for shock 3. It was evident that this added little. In this version, we have switched to shock 6 for obvious reasons.

Figure 20

Energy Usage - Shock 6 - Two Models

Billions of 1971 Dollars

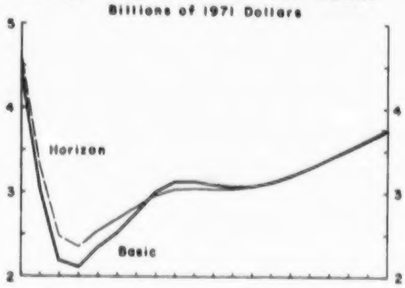


Figure 21

Gross Investment - Shock 6 - Two Models

Billions of 1971 Dollars

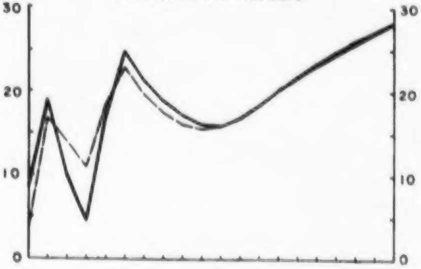


Figure 22

Real Wage Inflation - Shock 6 - Two Models

Percent per Annum

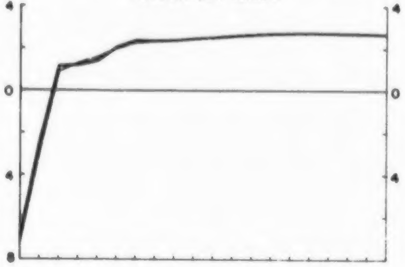


Figure 23

Output Price Inflation - Shock 6 - Two Models

Percent per Annum

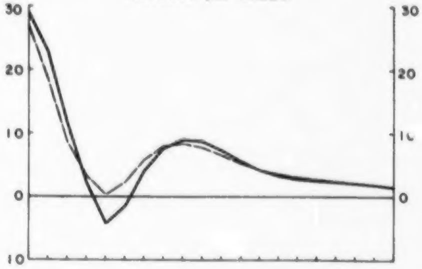


Figure 24

Purchasing-Power Parity Exchange Rate - Shock 6 - Two Models

Canadian Dollars per U.S. Dollar

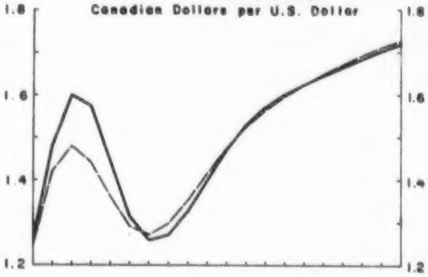


Figure 25

Wage/Energy Price - Shock 6 - Two Models

Thousand Dollars per Annum/Index 1971 = 1.0

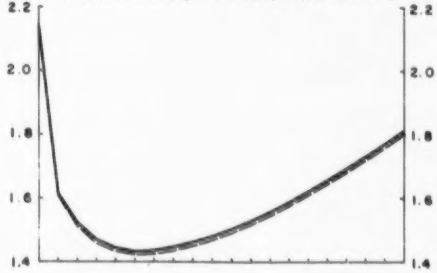


Figure 26

Real Output Growth - Shock 6 - Two Models

Percent per Annum

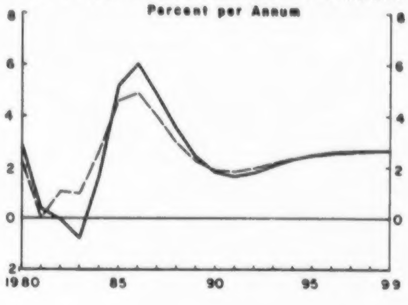
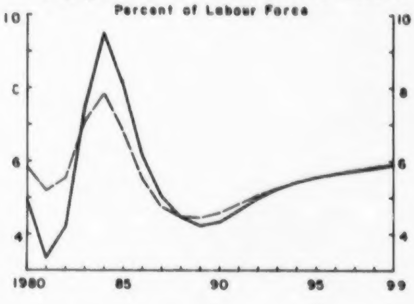


Figure 27

Unemployment Rate - Shock 6 - Two Models

Percent of Labour Force



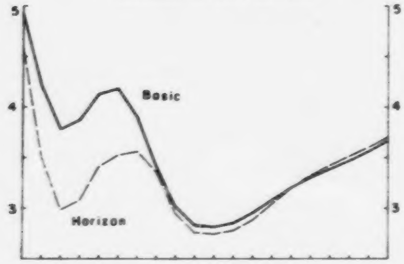


Figure 28
Energy Usage - Shock 2 - Two Models
Billions of 1971 Dollars

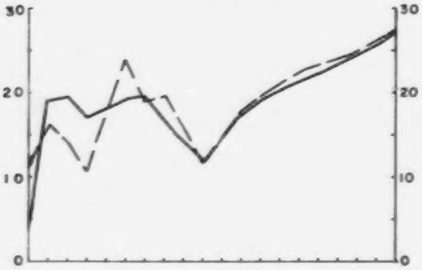


Figure 29
Gross Investment - Shock 2 - Two Models
Billions of 1971 Dollars

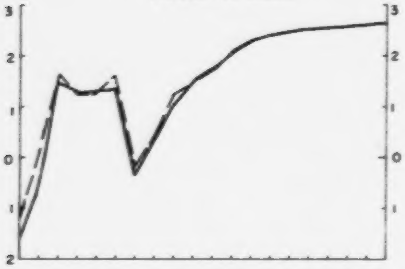


Figure 30
Real Wage Inflation - Shock 2 - Two Models
Percent per Annum

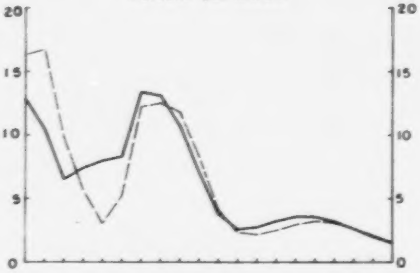


Figure 31
Output Price Inflation - Shock 2 - Two Models
Percent per Annum

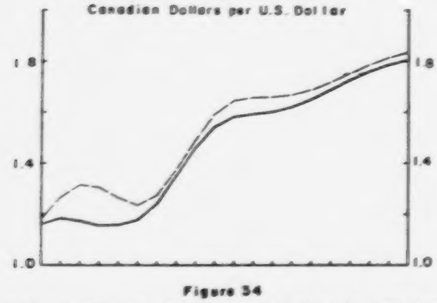


Figure 32
Purchasing-Power Parity Exchange Rate - Shock 2 - Two Models
Canadian Dollars per U.S. Dollar

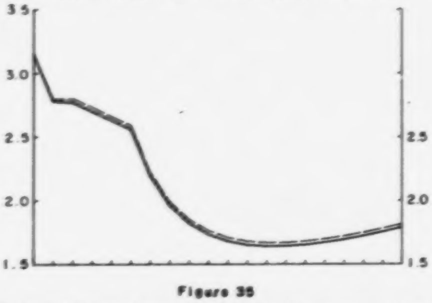


Figure 33
Wage/Energy Price - Shock 2 - Two Models
Thousand Dollars per Annum/Index 1971 = 1.0

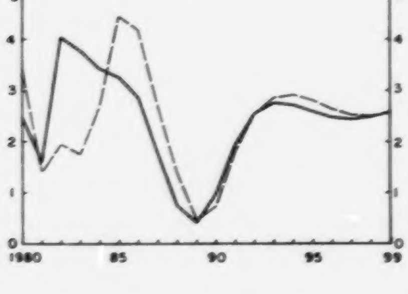


Figure 34
Rate of Growth of Output - Shock 2 - Two Models
Percent per Annum

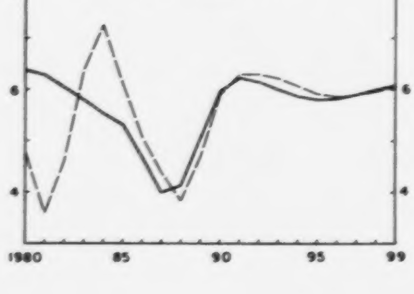


Figure 35
Rate of Unemployment - Shock 2 - Two Models
Percent of Labour Force

closing of the energy price gap for five years and at the same time provide firms with information on future real energy costs closely approximating what actually happens.[18] We can think of this as an announced real price path which is believed by the private sector and which actually comes to pass. Whether or not this could ever happen it provides an interesting "perfect foresight" experiment. It is important to note that the perfection is limited to real energy costs. Firms are not given exact information on all the endogenous responses in the model, so we are far from a perfect foresight rational expectations world. From Figure 28 we see that the pre-announced changes have an effect far in advance of the actual price changes. In fact we may have gone too far in lowering the discount rate as the results show perhaps too much response too soon. The principle is clear, however. The mechanism of forward-looking expectations can provide response to announced future factor price movements. To keep things in perspective we can provide some cross-shock comparisons. Energy use falls in this experiment a bit more than with the actual price changes of shock 1 over the 1980-85 period. However, the response is generally less than with shock 3. The absence of an actual energy price increase (relative to control) keeps actual inflation down and so there is less demand-side feedback. This dominates the direct effect of higher real wages and unemployment falls more than with shock 3 (though not as much as with basic shock 6). In general, the

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18. There are two reasons for the approximation. First, as noted in Section 3, real energy prices are not completely predetermined so we cannot impose exact perfect foresight without iterating on the results. Second, we use an approximate analytic solution to the forward integral, rather than using numerical methods to get an "exact" solution at each time point.

extra information, while leading to energy conservation in advance of the actual price changes, exacerbates cyclical response elsewhere. Furthermore, there is very little damping of the cycles when there is a delayed response. For example, the relative fall in the real growth rate is almost as severe when delayed in shock 2 as it was for basic shock 6. It appears from these results that delaying actual energy price adjustments cannot reduce the "costs" of adjustment over-all, in terms of output and other variables. In results not reported here, however, we have seen that when the vintage restriction is on, there are clear cycle-damping gains to giving prior information.

We are treating the energy price changes as relative price shocks and such shocks can have no permanent effect on the rate of inflation. The rate of inflation is determined, in the limit, by the money and real growth rates. However, in the adjustment process towards new relative factor prices, the instantaneous rate of inflation is affected and we have, potentially, a mechanism for a wage-price spiral which could lead to significant effects on the price level change over the adjustment period and on the time profile of the rate of inflation.

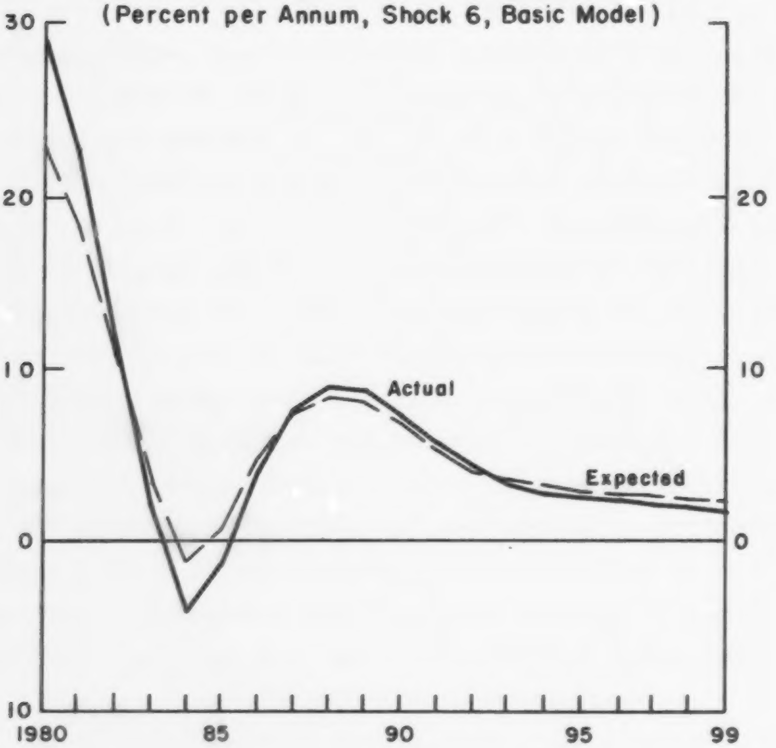
In comparing the shocks (Figures 7, 15, 23 and 31) we see that although the faster the increase of energy prices initially, the higher the rate of inflation, this effect is very short-lived. In fact the rapid approach shock 6 generates lower inflation over-all than the other shocks which end up in roughly the same place (i.e., world prices by 1999). We can see this by looking at the purchasing-power-parity exchange rate. The lower over-all inflation with shock 6 comes at the cost of a larger cyclical profile. Shock 3 ends up with virtually the same inflation over-all, lower initial inflation and lower "second peak" inflation. This result is very interesting. Shock 3 dominates shocks 1 and 2 on all counts except initial impact effects. Thus there is a payoff to adjusting faster at first, but only up to a point. When the extreme shock 6 is considered, we think it fairly clear that shock 3 results would be preferred. Of course, shocks 4 and 5 produce better inflation results, but at a cost of higher unemployment.

Throughout the discussion of results we have come across important effects of expectations lagging behind actual inflation when large changes in the latter are generated. In Figure 36 we plot, using our most extreme case (shock 6), the actual and endogenously generated expected rates of inflation (using a one-year horizon for this comparison). Notice that expectations do respond to the large impact effects. The expected rate of inflation roughly doubles from its control value. Yet there is still substantial underprediction as the actual rate rises by a factor of 2.4. After the first couple of years the expectations track the actual values quite closely though they are less extreme in their cyclical movements. It is impossible to say based on hard evidence whether these expectations are "reasonable", but we do not find the initial "surprise" implausible. But what of the later tracking and indeed the speed with which actual and expected rates vary? An important part of these experiments is that they represent relative price shocks which are treated as such by economic agents. Neither firms nor households are fooled into thinking that the result of a relative price shock is a change in the long-term trend rate of inflation. The short-term higher inflation is treated as a strictly local phenomenon. Hence, there is no long-lasting effect on wages from higher inflation expectations generated by short-term

Figure 36

Expected and Actual Output Price Inflation

(Percent per Annum, Shock 6, Basic Model)



bubbles. We think this is entirely defensible. For example, the shock 6 result of two years of 25 per cent and higher inflation is clearly an aberration with no permanent consequences and we feel that it would, by and large, be so interpreted. When the adjustment horizon is longer and the price changes more evenly spread over time the answer becomes less clear and there is perhaps more scope for confusion about relative price changes and inflation and more scope for resistance to the reduction of inflation from expectations which give less weight to the long-run role of money growth.

5 CONCLUSIONS

In this paper we have introduced a new model of the Canadian economy and used it to consider some possible consequences of different adjustment paths for real domestic energy prices to world levels. We produce no evidence that suggests there would be an unemployment problem in the face of a rapid rise in energy prices. Despite the initial downturn in output growth the results are characterized by an employment boom. A temporary stagflation of sorts emerges, in the sense that the downturn in output growth is often associated with a price inflation, reinforced by the excess demand in the labour market. We may have overstated the extent to which labour can be substituted for energy in the short run or perhaps have understated the negative effects on output (and hence labour demand), but our results show fairly clearly that factor substitution can be an important offset to potential unemployment problems that may be associated with the movement of energy prices to world levels.[19] Many models which do not have energy as a factor of production have had difficulty in recent periods explaining the strength of employment.

Measured as output per unit of employment, productivity falls when relative factor price changes stimulate a substitution towards labour. This is at least suggestive that some of the observed decline in measured productivity may reflect factor substitution and not any change in fundamental technological progress or productivity trends.

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[19] Evidence from other countries might seem to suggest that it is unreasonable to expect unemployment to actually fall in the short run. It is well to remember, though, that Canada has a significant energy supply sector and that the terms-of-trade and wealth effects absorbed by energy importers would not be so important here. This said, we ourselves have noted some aspects of the short-run dynamics of this version of SAM which may be questionable.

Finally let us turn to the questions of timing and cycles associated with different adjustment paths. We saw that very rapid adjustment towards world prices did tend to generate fairly substantial cyclical fluctuations. Delaying the adjustment, however, merely postponed and did not substantially diminish these cycles, even when the delayed real adjustment path was announced and acted on in advance (shock 2). Little is gained by having low rates of increase in the first years (shock 1), especially with respect to inflation. Indeed, the rapid approach shock 6 produces the lowest over-all price increase. A very interesting possibility emerges when comparing shocks 1, 3 and 6. Shock 3 has only very slightly less over-all inflation with a much more stable time profile. The initial higher measured inflation is very short-lived and not prolonged in a wage-price spiral. On the other hand, shock 1 produces slightly more stable unemployment results. Clearly there is scope here for some interesting optimal policy experiments.

THE MACROECONOMIC IMPACT OF INCREASED ENERGY PRICES FOR JAPAN

Hiroshi Yomo

BANK OF JAPAN

The views expressed in this paper are those of the author and no responsibility for them should be attributed to the Bank of Japan. The author wishes to thank K. Hiraiwa and T. Ikenega for assistance in the research of this paper.

1 INTRODUCTION

To begin, I would like to consider the channels of impact of the increased oil price on the macro economy. The impact will arise primarily in the following ways: (i) decreased nominal income caused by a deterioration in the terms of trade (that is, the deterioration in the current balance); (ii) depreciation of the exchange rate brought about by a reduction in the long-term expected rate because of a deterioration in the balance of payments; and (iii) a rise in domestic prices caused by energy cost pressure and a reduction in potential output because of a reduction in the oil input.

The decrease in nominal incomes and the increase in prices imply a decrease in real income, reinforced by a fall in the real value of monetary assets.

However, a few changes will occur to offset these deflationary movements. These are: (i) an increase in export volume caused by an improvement in international competitiveness based on exchange rate depreciation; and (ii) an increase in fixed investment to substitute oil as a production factor. Meanwhile, the price increase in the first stage raises expectations of inflation, leading to increases in the nominal wage and further price increases. Thus, the degree of impact of the increased oil price depends, to a large extent, upon the strength of this vicious circle. [5][7]

Section 2 explains how our econometric model deals with energy price increases. In Section 3, the simulation results with respect to a 10 per cent increase in the oil price are described. In Section 4, further research into supply disturbance analysis is considered and some initial results are presented.

2 THE ROLE OF ENERGY PRICES IN OUR MODEL

Our model contains the above-mentioned channels of influence of the increased oil price except for the effects on potential output and fixed investment.

Our approach is basically orthodox. Some of the notable characteristics of our model are as follows:

i) Wages are affected by nominal productivity. Therefore, a part of the burden caused by an increase in oil prices is passed directly from enterprises to employees.

Wage Function

$$\frac{W^*-W^*_{-4}}{W^*_{-4}} = \underset{(3.0)}{0.1193} + \underset{(7.4)}{0.7296} \sum_{0}^{1} (\tfrac{1}{2}) \left(\frac{CPIOR-CPIOR_{-4}}{CPIOR_{-4}}\right)$$

$$- \underset{(3.8)}{0.0597} \sum_{0}^{2} (\tfrac{1}{3}) \left(\frac{UELF}{LF}\right) * 100$$

$$+ \underset{(2.8)}{0.4482} \sum_{0}^{2} (\tfrac{1}{3}) \left(\frac{\{GNP \div (L*H)\} - \{GNP \div (L*H)\}_{-4}}{\{GNP \div (L*H)\}_{-4}}\right)$$

(1967Q2-1979Q1) $\overline{R}^2 = 0.910$ S.E.E. = 0.02 D.W. = 1.73

where

W* = wage rate per man-hour,
CPIOR = consumer price index,
UELF = number of unemployed,
LF = labour force,
GNP = gross national product,
L = number of persons at work, and
H = total hours worked per month per regular worker.

ii) The propensity to consume is affected by consumers' expectations of inflation. There seem to be two effects with opposite signs. One is the substitution effect between future and present consumption and the other is the income effect of the change in expected future real income. In the case of Japan, the former is smaller than the latter according to our estimation results. Therefore, an increase in the oil price reduces consumption because it raises expectations of inflation. In our consumption function, we adopt the consumers' confidence index (composite index derived from a survey of consumers) as an explanatory variable. Consumer confidence is, in turn, made a function of the inflation rate.

Consumption Function

$$C = \underset{(4.8)}{3711.0969} + \underset{(5.0)}{0.2317YD} + \underset{(6.2)}{0.6234}\left(\sum_{0}^{1}\left(\frac{1}{2}\right)\mathrm{CONF}\cdot\mathrm{PCA}\right) * YD \div 1000$$

$$+ \underset{(8.9)}{0.5988C}_{-1}$$

(1967Q3-1979Q1) $\overline{R}^2 = 0.997$ S.E.E. = 786.8 D.W. = 1.80

where

C = personal consumption,
YD = personal disposable income, and
CONF·PCA = index of consumers' confidence.

Consumers' Confidence Function

$$\mathrm{CONF{\cdot}PCA} = \underset{(28.4)}{102.9247} - \underset{(3.4)}{102.5263} \sum_{0}^{1} \left(\frac{1}{2}\right) \Delta \left(\frac{\mathrm{UELF}}{\mathrm{LF}}\right) * 100$$

$$+ \underset{(2.6)}{3.3038} \sum_{0}^{3} \frac{4-t}{10} \Delta \left(\frac{\mathrm{YD}}{\mathrm{YD}_{-4}}\right) * 100$$

$$- \underset{(2.2)}{2.7000} \sum_{0}^{3} \frac{4-t}{10} \Delta \left(\frac{\mathrm{CPIOR}}{\mathrm{CPIOR}_{-4}}\right) * 100 - \underset{(3.2)}{35.8714}\mathrm{DUM1}$$

$$- \underset{(1.1)}{4.8820}\mathrm{DUM2}$$

DUM1:73Q4=1.0
DUM2:74Q1 =1.0

(1971Q3–1979Q1) $\bar{R}^2 = 0.552$ S.E.E. = 10.1 D.W. = 1.24

where

CONF·PCA = index of consumers' confidence,
UELF = number of unemployed,
LF = labour force,
YD = personal disposable income, and
CPIOR = consumer price index.

3 SIMULATION RESULTS

In this section, the simulation results with respect to a 10 per cent increase in the oil price are described.[8] Simulations are done for two cases; in one, foreign variables are held fixed, while in the other, foreign variables are allowed to move. As foreign variables are exogenous to our model, they are assumed to change by using multipliers of other institutions' models (the OECD INTERLINK Model and the Project LINK Model). When variables (such as the oil price) that are relevant to the world economy change, the simulations might be more accurate if a model that links individual country models and allows for the interdependencies were used. Ours is a "second best" method.

The simulation results are presented in Tables 1 and 2. In the case of changed foreign variables, real GNP decreases .25 per cent in the first year but returns to .16 per cent below the level of the control solution in the third year. The size of the transfer of income to oil-producing countries caused by the increased oil price is about .7 per cent of nominal GNP. From this point of view, the extent of the decrease in real GNP is not large. Real activity shrinks less than real income owing to the habit mechanism that maintains consumption spending, and the effect of yen depreciation on the trade balance. The current balance deteriorates by $6.8 billion in the first year and by $5.8 billion in the third year. Meanwhile, the dollar increases in value by 7 yen in the first year and by 12 yen in the third year.

Consumer prices rise by only .22 per cent in the first year but by 1.24 per cent by the third year. Input-output analysis gives us .30 per cent as the impact on consumer prices of a 10 per cent increase in the oil price. The result of the simulation in the third year is larger because of the induced depreciation of the yen and the increase in the compensation of employees.

On the distribution side, in the first year nominal GNP, business profits and compensation of employees decrease by .52 per cent, 3.66 per cent and .11 per cent, respectively. By the third year, however, they increase by .43 per cent, .14 per cent and .83 per cent, respectively. I would like to

TABLE 1

IMPACT OF A 10 PER CENT INCREASE IN OIL PRICES:
DIFFERENCE BETWEEN SHOCK AND CONTROL

	Foreign Variables Unchanged			Foreign Variables Changed		
	1st year	2nd year	3rd year	1st year	2nd year	3rd year
Real GNP (%)	−0.08	−0.05	0.01	−0.25	−0.28	−0.16
Personal consumption	−0.14	−0.20	−0.11	−0.18	−0.33	−0.23
Private investment in residential construction	−0.02	−0.06	−0.07	−0.02	−0.07	−0.08
Private investment in plant and equipment	−0.04	−0.05	0.01	−0.06	−0.12	−0.06
Private inventory investment	0.04	0.07	0.03	0.02	0.06	0.02
Government expenditure	−0.11	−0.26	−0.31	−0.11	−0.26	−0.29
Domestic demand	−0.26	−0.49	−0.45	−0.34	−0.72	−0.65
Exports of goods and services	0.12	0.26	0.24	0.01	0.17	0.16
Imports of goods and services	0.06	0.18	0.21	0.08	0.27	0.33
Exports (billions $)	−0.7	0.1	−0.3	−2.0	−2.1	−2.5
Imports (billions $)	4.6	4.2	4.2	4.4	3.4	3.0
Current balance (billions $)	−5.7	−4.5	−4.9	−6.8	−5.7	−5.8
Exchange rate (Y/$)	6	9	9	7	12	12
Wholesale Price Index (%)	1.65	2.81	2.92	1.73	3.10	2.99
Consumer Price Index (%)	0.22	0.82	1.24	0.22	0.82	1.24
Nominal GNP (%)	−0.32	0.32	0.72	−0.52	0.00	0.43
Current profit of incorporated businesses (%)	−2.61	−0.14	1.10	−3.66	−1.64	0.14
Compensation of employees (%)	−0.01	0.63	1.14	−0.11	0.35	0.83

Notes: a) In the case of changed foreign variables, the GNP of the United States and the industrial production of OECD member countries except Japan and the United States are assumed to decrease .5 per cent through 3 years.

b) Sample period: 1980Q2-1983Q1.

c) All figures relating to GNP components are expressed in contributions to the differences in GNP between shock and control.

TABLE 2

IMPACT OF A 10 PER CENT INCREASE IN OIL PRICES: DIFFERENCE BETWEEN SHOCK AND CONTROL

	Foreign Variables Unchanged			Foreign Variables Changed		
	1st year	2nd year	3rd year	1st year	2nd year	3rd year
GNP deflator (%)	–0.32	0.38	0.67	–0.32	0.31	0.59
Wage cost	0.08	0.38	0.59	0.08	0.31	0.52
Profit per unit	–0.24	0.00	0.07	–0.24	0.00	0.07
Others	–0.16	0.00	0.00	–0.16	0.00	0.00
Share of labour (% point)	0.17	0.17	0.23	0.22	0.20	0.22
Share of profit (% point)	–0.17	–0.03	0.03	–0.23	–0.11	–0.02
Share of others (% point)	0.00	–0.14	–0.25	–0.01	–0.09	–0.19

Notes: a) All figures relating to the GNP deflator are expressed in contributions to the difference in the GNP deflator between shock and control.

b) Wage cost = compensation of employees / real GNP.
Profit per unit = business profit / real GNP.
Share of labour = compensation of employees / nominal GNP.
Share of profit = business profit / nominal GNP.

explain the mechanism and extent of the impact of the increased oil price on the distribution side in some detail. The mechanism is as follows: (i) An increase in the oil price causes an initial decrease in business profits since crude oil is an industrial input. Labour's share rises. (ii) In the next stage, firms pass on to other sectors the rise in their materials costs. Employees may have to share the burden caused by the increased oil price by submitting to a decrease in real wages. Hence, the profit share recovers and labour's share tends to decline. (iii) Next, workers try to raise their salaries to cover the decrease in real wages, which does lead to a rise in labour's share. This squeezes business profits and brings about a price increase -- a "home-made" inflation process.

According to our simulation results (Table 2, changed foreign variables case), labour's share rises .22 per cent in the first year and does not decline very much afterwards. Profit's share declines .23 per cent in the first year but returns almost to the level of the control solution in the third year. As a result, the share of the "others" category declines .19 per cent in the third year, where "others" includes property, income and the income of private unincorporated enterprises. As for inflation, the GNP deflator rises .59 per cent by the third year, mainly because of a rise in wage costs. This means that the wage response to an increase in the price of oil is apt to cause some home-made inflation.

4 FUTURE PROSPECTS AND A TENTATIVE RESULT

The effect on the supply side seems to be the most important among the factors that are not put in perspective in our simulations. Production is a function of the oil price via its effects on relative factor prices and factor demands. We are analyzing such supply-side phenomena in the context of building a medium-term annual forecasting model expected to be completed this year. This section presents a tentative result with respect to the relationship between the price of oil and potential output.

We can examine this relationship using an estimated production function. The first issue to be considered is the selection of the function type from among Cobb-Douglas, CES, translog, etc. This selection depends upon substitutability among production factors. Several analyses have been done with respect to substitutability, especially since the first oil crisis (Table 3).[2][6] While almost all analyses indicate substitutability between energy and labour, some analyses show complementarity between energy and capital. In Japan, however, we assume that both capital and labour are substitutes for energy over the medium term. In particular, we decided to use a Cobb-Douglas production function in which factors have a common elasticity of substitution of unity.

A Cobb-Douglas production function with an energy factor can be written as follows:

$$Y = Ae^{\delta t}K^{\alpha}L^{\beta}E^{\gamma}$$

$$\alpha + \beta + \gamma = 1 \qquad (1)$$

where

Y = output; K = capital; L = labour;
E = energy; δt = technological progress; and
A, α, β, γ = parameters.

We tried the following two approaches to estimate this function, attempting to avoid problems of multicollinearity among K, L and E. In each case capital is scaled by a capacity utilization index.

Ordinary Approach

This approach uses the assumption of homogeneity ($\alpha+\beta+\gamma=1$). By using this assumption, expression (1) is transformed into expression (2):

TABLE 3

SUMMARY OF EMPIRICAL FINDINGS ON SUBSTITUTION POSSIBILITIES BETWEEN ENERGY AND NON-ENERGY INPUTS

Study	Data Base	Findings
Berndt and Wood (1975)	U.S. manufacturing, 1947-1971	E and K comp. E and L sub. E and M sub.
Fuss (1977)	Canadian manufacturing by region, 1961-1971	E and L sub. E and M sub.
Griffin and Gregory (1976)	Nine OECD countries manufacturing, 1955, 1960, 1965, and 1969	E and K sub. E and L sub.
Hnyilicza (1975, 1976)	Energy and non-energy sectors of the U.S. economy, 1947-1971	For the non-energy sector: E and K ind. E and L ind. E and M sub. For the energy sector: E and K ind. E and L sub. E and M ind.
Ozatalay, Grubaugh, and Long (1978, 1979, undated)	Canada, West Germany, Japan, Netherlands, Norway, Sweden, United States, 1963-1974	E and K sub. E and L sub. (only in the long run) E and M ind.
Pindyck (1977)	Ten OECD countries manufacturing, 1959-1974 (or 1973)	E and K sub. E and L sub.

Notes: K = capital, L = labour, E = energy, M = materials, sub. = substitutes, ind. = independent, and comp. = complements

Factors of production were classified as independent if the elasticity of substitution had an absolute value close to zero, i.e., less than 0.1.

Source: U.S. Department of Energy, "Survey of the Research into Energy-Economy Interactions", 1979.

$$\frac{Y}{L} = Ae^{\delta t} \left(\frac{K}{L}\right)^{\alpha} \left(\frac{E}{L}\right)^{\beta} \tag{2}$$

Taking logs,

$$\log\left(\frac{Y}{L}\right) = \log A + \delta t + \alpha \log\left(\frac{K}{L}\right) + \beta \log\left(\frac{E}{L}\right) \tag{3}$$

The estimated result using annual data from 1955 to 1979 is:

$$\log\left(\frac{Y}{L}\right) = \underset{(8.3)}{1.308} + \underset{(2.4)}{0.014t} + \underset{(6.6)}{0.4646} \log\left(\frac{K' \cdot OCR}{L}\right)$$

$$+ \underset{(7.3)}{0.1569} \log\left(\frac{E}{L}\right)$$

(1955-1979) $\bar{R}^2 = 0.999$ S.E.E. $= 0.022$ D.W. $= 1.84$

where

Y = output;[1] L = man-hours; t = time trend;

K′= gross private non-residential fixed capital stock;

OCR = capacity utilization; and E = oil imports.

Rasche-Tatom Approach

This is the approach used by R.H. Rasche and J.A. Tatom in which the real energy price (energy price/output price) replaces energy volume in the estimated equations.[3] From marginal productivity theory,

---

[1] We define output as the sum of real GNP and oil imports owing to the explicit consideration of energy as a production factor.

$$\frac{\partial Y}{\partial E} = \frac{PE}{P}$$

where PE = energy price and P = output price.

So

$$E = \gamma Y \left(\frac{PE}{P}\right)^{-1} \qquad (2')$$

Substituting this expression into (1), we get

$$Y = \{A\gamma^{\gamma} e^{\delta t} K^{\alpha} L^{\beta} \left(\frac{PE}{P}\right)^{-\gamma}\}^{\frac{1}{1-\gamma}} \qquad (3')$$

Using the assumption of homogeneity and taking logs,

$$\log\left(\frac{Y}{L}\right) = \frac{1}{1-\gamma}\log A\gamma^{\gamma} + \frac{\delta}{1-\gamma}t + \frac{\alpha}{1-\gamma}\log\left(\frac{K}{L}\right) - \frac{\gamma}{1-\gamma}\log\left(\frac{PE}{P}\right) \qquad (4')$$

The estimated result is:

$$\log\left(\frac{Y}{L}\right) = \underset{(4.6)}{0.4334} + \underset{(2.2)}{0.0192t} + \underset{(7.1)}{0.622}\log\left(\frac{K' \cdot OCR}{L}\right) - \underset{(4.2)}{0.0564}\log\left(\frac{PE}{P}\right)$$

(1955–1979) $\overline{R}^2 = 0.997$ S.E.E. = 0.031 D.W. = 1.16

where

Y = output;   L = man-hours;   t = time trend;
K′= gross private non-residential fixed capital stock;
OCR = capacity utilization; PE = oil import price; and
P = output price.[2]

The elasticities of the respective factors relative to output in these estimated results are presented in Table 4. Elasticities would be equal to factor shares of output (presented in Table 4) under conditions of perfect competition. From this point of view, we prefer result (b) (Figure 1).[4]

TABLE 4

ELASTICITIES AND SHARES OF RESPECTIVE FACTORS

	Elasticities		Shares
	(a)	(b)	
Capital	0.4646	0.5887	0.5421
Labour	0.3785	0.3579	0.4428
Oil	0.1569	0.0534	0.0151

Note: Labour's share $= \frac{\text{Compensation of Employees}}{\text{Nominal Output}}$

Oil's share $= \frac{\text{Nominal Oil Imports}}{\text{Nominal Output}}$

Capital's share = residual

---

[2] $\frac{\text{Nominal GNP + Nominal Oil Imports}}{\text{Real GNP + Real Oil Imports}}$

Figure 1

TINBERGEN CHART OF RESULT (b)

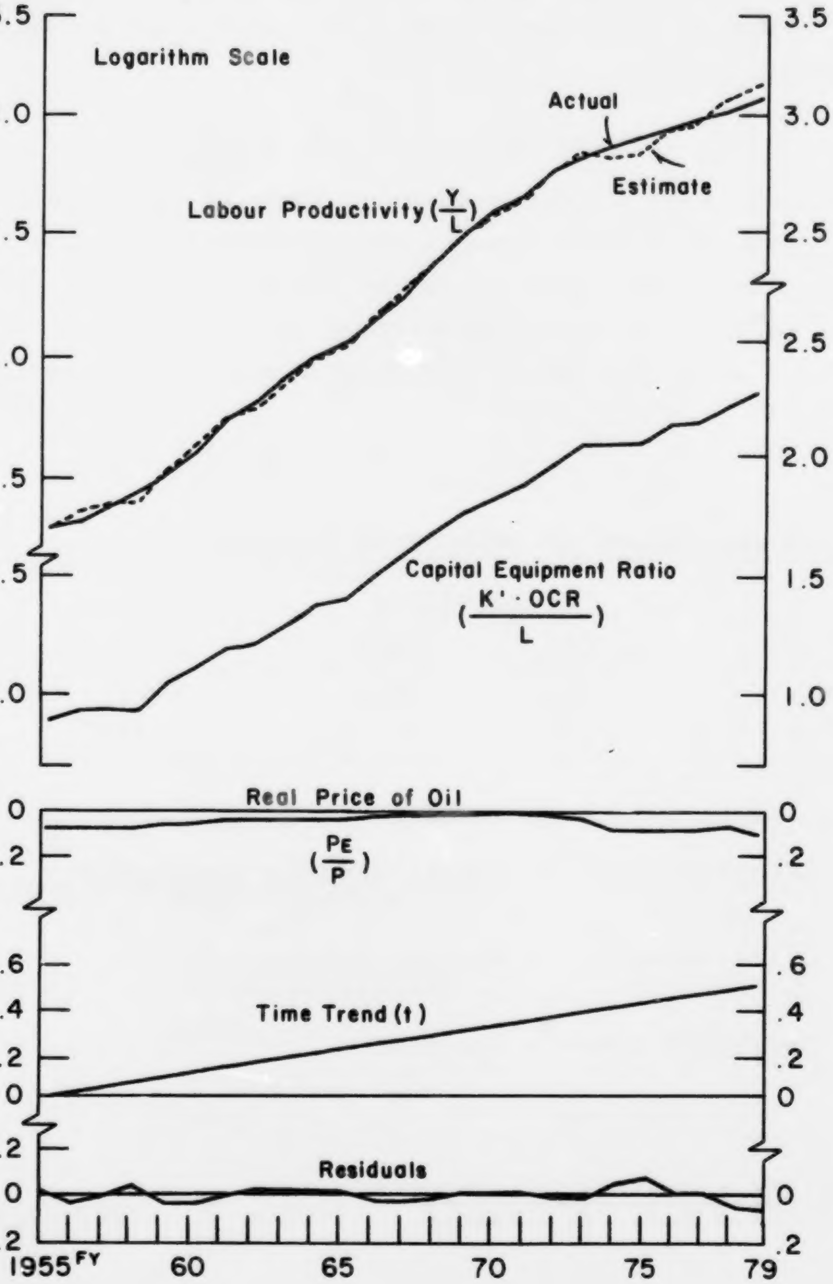
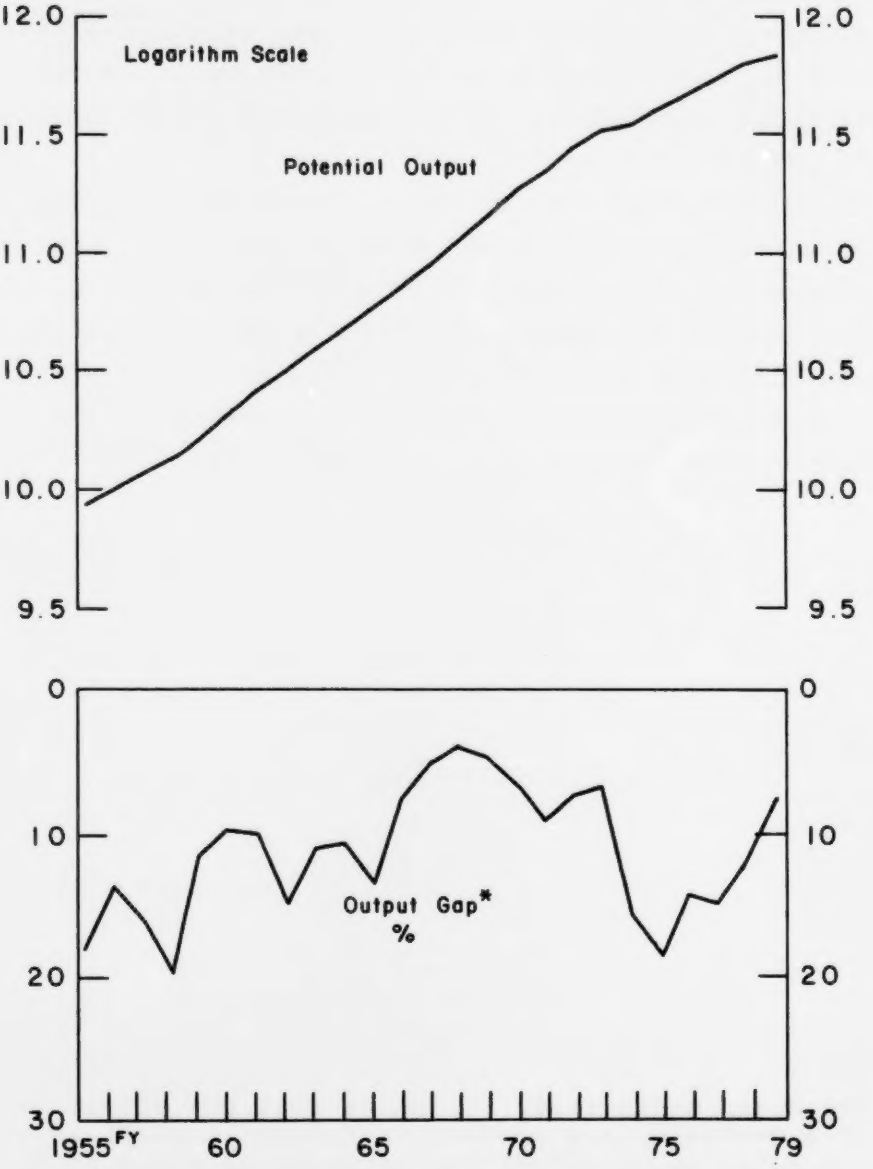


Figure 2

THE POTENTIAL OUTPUT AND OUTPUT GAP CALCULATED BY USING PRODUCTION FUNCTION



* $\frac{\text{Actual Output} - \text{Potential Output}}{\text{Potential Output}}$

We have also estimated a CES function. The result gives an elasticity of substitution of .68 which implies that the Cobb-Douglas premise (elasticity = 1.0) is not too unreasonable.[3]

Potential output and the output gap calculated using our production function are presented in Figure 2. Potential output grows more slowly in 1974 and 1979 when big increases in oil prices occurred.

We believe that the impact of increased oil prices on potential output is large and that it should be considered in the simulation with respect to the oil shock. This consideration will amplify the price increases and the decreases in real activity reported in the above simulations. However, experiments explicitly incorporating this kind of production function are left as a future task.

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3. The Hogan-Manne study [1] shows that the effect on output of a decrease in a production factor is small in the long run owing to an offsetting increase in other factors if the elasticity of substitution is greater than 0.5.

APPENDIX
LIST OF MAIN EQUATIONS

Personal Consumption

$$C = \underset{(4.8)}{3711.0969} + \underset{(5.0)}{0.2317}YD + \underset{(6.2)}{0.6234}\left(\sum_{0}^{1} \left(\frac{1}{2}\right) CONF \cdot PCA\right) * YD \div 1000$$

$$+ \underset{(8.9)}{0.5988}C_{-1}$$

(1967Q3-1979Q1) $\overline{R}^2 = 0.997$ S.E.E. = 786.8 D.W. = 1.80

Index of Consumers' Confidence

$$CONF \cdot PCA = \underset{(28.4)}{102.9247} - \underset{(3.4)}{102.5263} \sum_{0}^{1} \left(\frac{1}{2}\right) \Delta \left(\frac{UELF}{LF}\right) * 100$$

$$+ \underset{(2.6)}{3.3038} \sum_{0}^{3} \frac{4-t}{10} \Delta \left(\frac{YD}{YD_{-4}}\right) * 100$$

$$- \underset{(2.2)}{2.7000} \sum_{0}^{3} \frac{4-t}{10} \Delta \left(\frac{CPIOR}{CPIOR_{-4}}\right) * 100 - \underset{(3.2)}{35.8714}DUM1$$

$$- \underset{(1.1)}{4.8820}DUM2$$

DUM1=73Q4=1.0

DUM2=74Q1=1.0

(1971Q3-1979Q1) $\overline{R}^2 = 0.552$ S.E.E. = 10.1 D.W. = 1.24

Private Investment in Residential Construction

$$IH = \underset{(2.1)}{650.9036} + \underset{(2.8)}{2.4746}\left(\frac{YD}{PIH}\right)_{-1}$$

$$+ \underset{(2.7)}{4.8811}\frac{\sum_{0}^{1}\left(\frac{1}{2}\right)\Delta(LBH+LBCE+LGH)}{PIH_{-1}} + \underset{(7.5)}{0.6535}IH_{-1}$$

(1967Q2-1979Q1) $\overline{R}^2 = 0.954$ S.E.E. = 479.2 D.W. = 1.95

Private Investment in Plant and Equipment: Manufacturing

$$IFM - RM = \underset{(0.2)}{120.7184} + \underset{(13.7)}{114.6687}\sum_{0}^{13} w\left(\left\{\sum_{0}^{7}\left(\frac{1}{8}\right)\left(\frac{O}{O_{-1}}\right)\right\}^{8}\right.$$

$$\left. * \; 0.723O_{-1} - PO^{*}_{-1}\right) + \underset{(6.9)}{45.0391}\sum_{1}^{2}\left(\frac{1}{2}\right)O$$

$$+ \underset{(6.3)}{455.2652}\sum_{0}^{5}\left(\frac{1}{6}\right)\left(\frac{PROFITM*100}{KFN*\frac{KM}{KF^{*}}}RLD\right)$$

$$+ \underset{(3.4)}{0.3088}\sum_{1}^{6}\left(\frac{1}{6}\right)\Delta(AVIM*O) - \underset{(8,6)}{2237.9723}DUM3$$

w = 0.0250, 0.0464, 0.0643, 0.0786, 0.0893, 0.0964, 0.1000
0.1000, 0.0964, 0.0893, 0.0786, 0.0643, 0.0464, 0.0250

DUM3=1978Q3-1980Q3=1.0

(1968Q4-1980Q3) $\overline{R}^2 = 0.921$ S.E.E. = 447.7 D.W. = 1.88

Private Investment in Plant and Equipment: Non-Manufacturing Excluding Electricity, Gas and Water Supplies

$$
\begin{aligned}
IFN - EI(IFN) = {} & \underset{(0.2)}{-125.9664} + \underset{(2.9)}{2.7629} \sum_{0}^{2} w \left(\left(\sum_{0}^{5} \left(\tfrac{1}{6}\right) \frac{FD1^*}{FD1^*_{-1}} \right)^{6} \cdot FD1^*_{-1} \right) \\
& \div 100 + \underset{(1.7)}{0.1229} \left(\sum_{0}^{7} \left(\tfrac{1}{8}\right) \left\{ \left(\frac{PROFITN*100}{KFN*\frac{KN}{KF^*}} \right) RLD \right\} \right) \\
& \cdot \left(\left(\sum_{0}^{5} \left(\tfrac{1}{6}\right) \frac{FD1^*}{FD1^*_{-1}} \right)^{6} \cdot FD1^*_{-1} \right) \div 100 \\
& + \underset{(3.5)}{15.5893} \sum_{0}^{2} \left(\tfrac{1}{3}\right) \Delta \left(AVIM \cdot \left\{ \sum_{0}^{5} \left(\tfrac{1}{6}\right) \frac{FD1^*}{FD1^*_{-1}} \right\}^{6} \right. \\
& \left. \cdot\, FD1^*_{-1} * 10^{-5} \right) + \underset{(6.6)}{0.6100} \left(IFN-EI(IFN) \right)_{-1}
\end{aligned}
$$

$W = 0.25, 0.50, 0.25$

(1967Q4-1980Q3) $\overline{R}^2 = 0.981$ S.E.E. = 401.9 D.W. = 2.08

Private Inventory Investment

$$\begin{aligned}\mathrm{IIP{-}EI(IIP)} = & -\underset{(2.4)}{45448.612} + \underset{(4.5)}{127.84960} + \underset{(2.6)}{47134.95}\sum_{0}^{2}\left(\frac{1}{3}\right)\left(\frac{\mathrm{FD1}^{*}}{\mathrm{FD1}^{*}}\right) \\ & + \underset{(3.7)}{324.7488}\mathrm{EWPIM2}_{-1} - \underset{(1.8)}{0.5903}*10^{-2}\left(\sum_{0}^{5} w\,(\mathrm{RLD{-}EWPIM1})\right) \\ & * \frac{\mathrm{LBPSA}_{-1}}{100} + \underset{(3.0)}{0.0336} * 10^{-2}\sum_{0}^{1}\left(\frac{1}{2}\right)\Delta\,(\mathrm{AVIM*GNP}) \\ & - \underset{(5.4)}{0.3599}\mathrm{KIIP}_{-1} - \underset{(3.0)}{0.137658}\left(\Delta\mathrm{FD2}^{*} - \sum_{1}^{4}\left(\frac{5-t}{10}\right)\Delta\mathrm{FD2}^{*}\right)\end{aligned}$$

w = 0.10, 0.15, 0.25, 0.25, 0.15, 0.10

(1967Q2-1979Q1) $\bar{R}^2 = 0.743$ S.E.E. = 724.4 D.W. = 1.77

Wage Rate per Man-hour

$$\begin{aligned}\frac{W^{*}-W^{*}_{-4}}{W^{*}_{-4}} = & \underset{(3.0)}{0.1193} + \underset{(7.4)}{0.7296}\sum_{0}^{1}\left(\frac{1}{2}\right)\left(\frac{\mathrm{CPIOR}-\mathrm{CPIOR}_{-4}}{\mathrm{CPIOR}_{-4}}\right) \\ & - \underset{(3.8)}{0.0597}\sum_{0}^{2}\left(\frac{1}{3}\right)\left(\frac{\mathrm{UELF}}{\mathrm{LF}}\right)*100 \\ & + \underset{(2.8)}{0.4482}\sum_{0}^{2}\left(\frac{1}{3}\right)\left(\frac{\{\mathrm{GNP}\div(\mathrm{L*H})\}-\{\mathrm{GNP}\div(\mathrm{L*H})\}_{-4}}{\{\mathrm{GNP}\div(\mathrm{L*H})\}_{-4}}\right)\end{aligned}$$

(1967Q2-1979Q1) $\bar{R}^2 = 0.910$ S.E.E. = 0.02 D.W. = 1.73

Business Value Added

$$\log VA = \underset{(12.3)}{-1.6564} + \underset{(98.2)}{1.1487} * \log(GNP - 0.828 * CG - IIG)$$

(1967Q2-1979Q1) $\bar{R}^2 = 0.995$ S.E.E. = 0.04 D.W. = 0.17

Wholesale Price Index

$$\begin{aligned}
WPIOR &- 0.0164 WPIRWOR \\
&- 0.0255 WPIEGOR = \underset{(33.2)}{24.4076} \\
&+ \underset{(58.8)}{118.8003} \left\{ 67.8847 \sum_{0}^{3} \frac{4-t}{10} \left(\frac{W^* * LWH}{GNP} \right) \right. \\
&\left. + \sum_{0}^{3} \frac{4-t}{10} \left(\frac{MC^* * IBDR(A)}{GNP} \right) \right\} \div 100 + \underset{(8.4)}{0.1486} EDJM \\
&* \left\{ 67.8847 \sum_{0}^{3} \frac{4-t}{10} \left(\frac{W^* * LWH}{GNP} \right) \right. \\
&\left. + \sum_{0}^{3} \frac{4-t}{10} \left(\frac{MC^* * IBDR(A)}{GNP} \right) \right\} \div 100
\end{aligned}$$

(1967Q2-1979Q1) $\bar{R}^2 = 0.994$ S.E.E. = 1.42 D.W. = 0.48

Consumer Price Index

$$\log\{(\mathrm{CPIOR} - 0.1563\mathrm{CPIPSOR} - 0.2207\mathrm{CPISIOR})0.6230\} = \underset{(5.6)}{0.7155} + \underset{(19.1)}{0.3535} \log \sum_{0}^{2} w_1 W^*$$

$$+ \underset{(19.2)}{0.6017} \sum_{0}^{3} w_2 \mathrm{WPIMOR}$$

$$+ \underset{(2.8)}{0.4221} \log\left(\frac{\sum_{1}^{2} (\frac{1}{2}) C}{\sum_{1}^{8} (\frac{1}{8}) C}\right)$$

$$+ \underset{(2.2)}{0.0056}\mathrm{DUM16} + \underset{(3.0)}{0.0199}\mathrm{DUM17}$$

$w_1 = 0.25, 0.5, 0.25$

$w_2 = 0.17, 0.33, 0.33, 0.17$

DUM16=1969Q2-1970Q1=1.0, 1970Q2-1971Q1=2.0

1971Q2-1972Q1=3.0, DUM17 = 1974Q1, 2, 3 =1.0

(1968Q2-1980Q4) $\overline{R}^2 = 0.999$ S.E.E. = 0.01 D.W. = 0.51

Export Price Index, Customs Clearance Basis, in Dollar Terms, Real

$$\log \mathrm{PECSA} + 0.3 \log \frac{360}{\mathrm{RECHUSA}} = \underset{(5.7)}{3.1693} - \underset{(5.2)}{0.3485} \log \sum_{1}^{2} w_1 \frac{360}{\mathrm{RECHUSA}}$$

$$+ \underset{(5.8)}{0.6873} \log \sum_{1}^{2} w_2 \mathrm{WPIM}$$

$$+ \underset{(2.6)}{0.2260} \log \mathrm{PEXISA}$$

$$+ \underset{(2.3)}{0.1582} \sum_{0}^{2} w_3 * \mathrm{OCR}$$

Export Price Index (continued)

w_1 = 0.5, 0.1
w_2 = 0.5, 0.5
w_3 = 0.25, 0.50, 0.25

(1967Q2-1980Q4) $\overline{R}^2 = 0.993$ S.E.E. = 0.03 D.W. 0.76

Exports of Goods to the United States, Customs Clearance Basis in Dollar Terms, Real

$$\log(\text{ECUSA}) = \underset{(18.9)}{-20.3994} + \underset{(35.7)}{4.2323} \log \sum_{0}^{1} \left(\frac{1}{2}\right) \text{VUSA}$$

$$+ \underset{(12.0)}{0.5633} \log \sum_{1}^{7} w_1 \left(\frac{\text{IFM}}{\text{GNP}}\right) - \underset{(1.3)}{0.1536} \log \sum_{0}^{1} \left(\frac{1}{2}\right) \text{OCR}$$

$$+ \underset{(10.3)}{1.6755} \sum_{0}^{5} w_2 \log \left(\frac{0.7 * \text{WPIUSEXF} + 0.3 * \text{PEXEUS}}{\text{PECSA}}\right)$$

$$- \underset{(6.1)}{0.1802} \text{DUM20}$$

w_1 = 0.075, 0.13, 0.18, 0.23, 0.18, 0.13, 0.075
w_2 = 0.107, 0.179, 0.214, 0.214, 0.179, 0.107

DUM20=1973Q2-1974Q1=1.0

(1967Q2-1980Q3) $\overline{R}^2 = 0.978$ S.E.E. = 0.05 D.W. = 1.02

Exports of Goods to Other Areas, Customs Clearance Basis, in Dollar Terms, Real

$$
\begin{aligned}
\log(EC^*OTH) = {} & \underset{(1.0)}{0.7970} + \underset{(6.5)}{1.3374} \log \sum_{0}^{1} \left(\frac{1}{2}\right) OECDEUJ \\
& + \underset{(4.8)}{0.5143} \log \sum_{1}^{8} \left(\frac{1}{8}\right) \{IM-EI(IM)\} \\
& - \underset{(4.1)}{0.5760} \log \sum_{0}^{1} \left(\frac{1}{2}\right) OCR \\
& + \underset{(10.8)}{1.3708} \sum_{0}^{5} w_1 \log \left(\frac{PEXISA}{PECSA}\right)
\end{aligned}
$$

w = 0.107, 0.179, 0.214, 0.214, 0.179, 0.107

(1967Q2-1980Q3) $\bar{R}^2 = 0.994$ S.E.E. = 0.04 D.W. = 1.23

Imports of Petroleum Crude and Partly Refined, Customs Clearance Basis, in Dollar Terms, Real

$$
\begin{aligned}
\log MC^*O = {} & \underset{(3.4)}{1.0477} + \underset{(2.1)}{0.2898} \log \sum_{1}^{3} \left(\frac{1}{3}\right) O \\
& + \underset{(6.6)}{0.7179} \log MC^*O_{-1}
\end{aligned}
$$

(1967Q2-1979Q1) $\bar{R}^2 = 0.975$ S.E.E. = 0.04 D.W. = 2.34

Imports of Manufactured Goods, Customs Clearance Basis, in Dollar Terms, Real

$$\log MC^{*}MA = \underset{(3.3)}{-3.0412} + \underset{(5.8)}{0.8411} \log \sum_{0}^{1} \left(\frac{2-t}{3}\right) FD1^{*}$$

$$+ \underset{(3.8)}{0.6478} \sum_{0}^{4} w \log WPIM$$

$$- \underset{(4.9)}{1.1847} \sum_{0}^{4} w \log PMCMA(Y) + \underset{(4.4)}{0.4304} \log MC^{*}MA_{-1}$$

$w = 0.1429, 0.2285, 0.2572, 0.2285, 0.1429$

(1967Q2-1979Q1) $\overline{R}^2 = 0.978$ S.E.E. = 0.06 D.W. = 1.52

Imports of Foodstuffs and Raw Materials, Customs Clearance Basis, in Dollar Terms, Real

$$\log MC^{*}NOM = \underset{(1.6)}{3.2804} + \underset{(3.3)}{0.5185} \sum_{0}^{3} \left(\frac{4-t}{10}\right) \log O + \underset{(2.6)}{0.4040} \sum_{0}^{3} w_1 \log C$$

$$- \underset{(0.9)}{0.3006} \sum_{0}^{6} w_2 \log \left(\frac{PMCNOM}{PMCNOM_{-1}} * 100\right)$$

$w_1 = 0.22, 0.32, 0.30, 0.16$

$$w_2 = \underset{(1.7)}{-1.030}, \underset{(1.7)}{-0.459}, \underset{(0.0)}{0.004}, \underset{(1.2)}{0.359}, \underset{(2.6)}{0.606}, \underset{(3.7)}{0.745}, \underset{(1.4)}{0.775}$$

(Almon lag weight)

(1967Q2-1979Q1) $\overline{R}^2 = 0.940$ S.E.E. = 0.05 D.W. = 1.46

Spot Exchange Rate [Yen/Dollar], Quarterly Average of Three Month-ends

$$
\begin{aligned}
\mathrm{IBDR} = {} & -3.4657-173.1226\sum_{0}^{2} w_1 \frac{\mathrm{BFXOR}}{\mathrm{ECXOR+ER+MCXOR+MP}} \\
& -36.573\,\Delta\left(\frac{\mathrm{BFXOR}}{\mathrm{ECXOR+ER+MCXOR+MP}}\right) \\
& -64.1835\sum_{0}^{1} w_2 \left\{\left(\frac{\mathrm{USM2OR\cdot A}}{\mathrm{USO}}\right)\Big/\left(\frac{\mathrm{USM2OR\cdot A}_{-4}}{\mathrm{USO}_{-4}}\right)\right. \\
& \left. -\left(\frac{\mathrm{M2CDOR\cdot A}}{\mathrm{O}}\right)\Big/\left(\frac{\mathrm{M2CDOR\cdot A}_{-4}}{\mathrm{O}_{-4}}\right)\right\} + 0.9916\,\mathrm{IBDR}_{-1}
\end{aligned}
$$

w_1 = 0.5778, 0.4000, 0.0222

w_2 = 0.6667, 0.3333

Estimated on monthly basis and transformed into quarterly type.

DATA AND NOTATION

AVIM	manufacturing firms' judgement on their financial positions, diffusion index
BFXOR	basic balance (balance of payments basis)
C	personal consumption
CG	government consumption
CONF·PCA	index of consumers' confidence
CPIOR	consumer price index
CPIPSOR	consumer price index, public services
CPISIOR	consumer price index, seasonal items
EC*	exports of goods on a customs clearance basis
ECXOR	exports of goods (balance of payments basis)
EDJM	manufacturing firms' judgement on supply-demand situation of their finished goods, diffusion index
EI(IFN)	emergency imports (private investment in plant and equipment, non-manufacturing excluding electricity, gas and water supplies)
EI(IIP)	emergency imports of private inventory
EI(IM)	emergency imports of goods and services
ER	exports of services (balance of trade basis)
EWPIM	proxy for expected inflation rate
FD	final demand
GNP	gross national product
H	monthly total hours worked per regular worker (all industries, excluding service industries)
IBDR(A)	spot exchange rate for U.S. dollars in yen (median inter-bank rate, overnight delivery)

DATA AND NOTATION

IFM	private investment in plant and equipment, manufacturing (on construction basis)
IFN	private investment in plant and equipment, non-manufacturing excluding electricity, gas and water supplies
IIG	government inventory investment
IIP	private inventory investment
IM	imports of goods and services (national income basis)
KF*	gross private fixed capital stock
KFN	net private fixed capital stock
KIIP	private inventory stock
KM	gross private fixed capital stock, manufacturing (on construction basis)
KN	gross private fixed capital stock, non-manufacturing excluding electricity, gas and water supplies (on construction basis)
L	number of persons at work
LBCE	loans and discounts of all banks and mutual loan and savings banks to construction and real estate industries
LBH	housing loans of all banks and mutual loan and savings banks
LBPSA	loans and discounts of all banks to private non-financial sector
LF	labour force
LGH	private housing loans of the housing loan corporation
LWH	man-hours (employees)

DATA AND NOTATION

M2CDOR·A	money and quasi-money plus certificates of deposit
MA	manufactured goods
MC*	imports of goods (customs clearance basis)
MCXOR	imports of goods (balance of payments statistics)
MP	imports of services (balance of payments basis)
O	index of industrial production
OCR	index of capacity utilization
OECDEUJ	index of industrial production of OECD member countries excluding Japan and the United States
PECSA	export price index (customs clearance basis)
PEXEUS	export price index of main industrial countries excluding Japan and the United States
PEXISA	export price index of main industrial countries excluding Japan
PIH	implicit price deflator, private investment in residential construction
PMCMA	import price index, manufactured goods (customs clearance basis)
PMCNOM	import price index, foodstuffs and raw materials excluding petroleum crude and partly refined (customs clearance basis)
PO*	index of production capacity, manufacturing (MITI basis)
PROFITM	current profit, manufacturing (financial statements of incorporated businesses)
PROFITN	current profit, non-manufacturing excluding electricity, gas and water supplies (financial statements of incorporated businesses)

DATA AND NOTATION

RECHUSA	index of effective exchange rate
RLD	average contracted interest rate on loans and discounts, all banks
RM	discards of private fixed capital stock, manufacturing
UELF	number of unemployed
USM2OR A	money supply (M2) of the United States
USO	industrial production index of the United States
VA	business value added
VUSA	real GNP of the United States
W*	wage rate per man-hour
WPIEGOR	wholesale price index, electricity and gas
WPIMOR	wholesale price index, manufactured goods
WPIOR	wholesale price index
WPIRWOR	wholesale price index, rice and wheat
WPIUSEXF	wholesale price index, manufactured goods excluding fuels and energy
YD	personal disposable income

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DISCUSSION

Although the incorporation of energy into the production function and the modelling of expectations impressed Peter Hooper as significant achievements, he was skeptical about the particular specifications. More rapid approach to world oil prices produces a labour market boom. The relatively high elasticity of substitution between energy and labour that is crucial to this result depends on the assumed form of the production function. Since there is ample international experience that contradicts the SAM predictions, Hooper asked for corroborative evidence to support the specification. As regards the dynamic properties, he thought the cyclical fluctuations excessive, and surmised that this was due to a simplified inventory reaction in this version of SAM. David Rose pointed out that real wages fall with rapid decontrol of energy prices as the inflation is not at first fully anticipated. This in part explains the labour market cycle.

Various discussants were concerned that the behaviour of the price level and exchange rate depended on implicit monetary assumptions, and questioned the substantial differences in these variables in the different simulations. There was some confusion as to whether this implied large shifts in monetary velocity and interest rates. Rose admitted that the monetary assumptions were not clear given the absence of the financial sector from the simulations. Money is implicitly assumed to behave in such a way as to fix the real cost of capital at a constant level. Hooper and others regarded the lack of explicit modelling of money demand and supply and exchange rate behaviour from these simulations as a significant omission.

A more conventional, demand-side-oriented model was presented by Hiroshi Yomo. David Longworth pointed out that, although the results were much as one would expect (increased prices of energy imports cause GNP in Japan to decline, prices to rise and the yen to fall), the only reason GNP falls is that in the model government expenditure is fixed in nominal terms. Otherwise, the strong impact of the depreciation of the yen on the real trade balance would cause GNP to increase. Longworth thought that dummy variables for OPEC I in the consumer confidence equation and the consumer price index equation may obscure factors generated by an oil price shock. He also thought that the decline in the ratio of Japanese oil imports to output warrants inclusion of the real price of oil in the petroleum import equation.

In an interesting aside that illustrates the different attitudes among members of the profession on the precision of econometric estimates, Longworth contrasted Hiroshi Yomo's view that his .68 elasticity of substitution is _not_ much different from unity with David Rose's view that his .89 _is_!

EXTERNAL SHOCKS AND POLICY RESPONSES IN A SMALL EXTERNALLY DEPENDENT ECONOMY

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Reserve Bank of New Zealand

This is a shortened version of the paper presented at the Conference [5]. The authors thank G.H. Spencer and K.G. Duggan for their assistance with the preparation of this paper. The views expressed here are those of the authors and do not purport to represent the views of the Reserve Bank of New Zealand.

1 INTRODUCTION

This paper discusses the nature of the impact of external shocks on the New Zealand economy and offers some analysis of the macroeconomic policy response to these shocks. In order to constrain the discussion within reasonable bounds, the paper concentrates upon the particular forms of shocks that have been experienced over the past decade. Such events as the major oil price rises in 1973 and 1979, the persistence of relatively slow growth and high but variable inflation rates in the industrial economies, and the difficulties with overseas market access for New Zealand's exports have each tended to be reflected primarily in price fluctuations for traded goods rather than in variations in export and import volumes. As far as the policy responses are concerned, the paper concentrates mainly upon the broad instruments of macroeconomic policy, including the exchange rate and monetary and fiscal policies, rather than upon the use of direct controls such as protective measures, incomes policies, and export incentives.

The paper initially provides a sketch of some of the major features that have characterized the New Zealand economic situation over the past decade and then presents results from some simulation experiments on these issues using one of the latest versions of the Reserve Bank's Core model. The main emphasis is on experiments covering:

(i) two types of imposed hypothetical external shocks (higher import prices, lower export prices);

(ii) three exchange rate policy responses to each of these shocks;

(iii) a domestic policy response to the same shocks in the form of reduced government spending; and

(iv) alternative exchange rate and domestic policy responses to actual history, involving holding the 1975(4) peak real exchange rate, together with reduced government spending and higher domestic interest rates.

The discussion then endeavours to draw together some of the general principles that emerge from the New Zealand experience and the empirical work that has been carried out with respect to this experience.

2 THE NEW ZEALAND ECONOMY

Although New Zealand's external trade to GNP ratios are not unduly high by international standards, the country could probably be fairly described as having a relatively high degree of external dependence. This is because the historical concentration on a relatively narrow range of primary export products, the volatility of export price movements and especially the variability in the terms of trade, have implied that New Zealand has been exposed to external shocks on a scale matched by few other OECD countries. Moreover, the bulk of New Zealand's imports are raw materials, components and capital equipment; a low proportion of finished goods are imported which suggests another form of external dependence insofar as domestic production and employment are concerned. For these reasons it is often argued that the rate of economic growth in New Zealand is significantly constrained by the state of the external accounts and, given the absence of major private capital flows, the current account in particular.

Thus, despite being a country of moderate affluence by international standards, New Zealand shares a number of important structural features with the developing countries, many of which have external dependence characteristics not unlike those of New Zealand.

In a similar vein, the major shocks experienced by the New Zealand economy over the past decade have been similar to those encountered by the developing countries. These include the massive oil price increases in 1973 and again in 1979, and the sharp fluctuations that have occurred in the terms of trade as a consequence of higher and more variable inflation rates in the international economy and the sharp cyclical swings in prices for many pastoral and primary commodities. Allied with these difficulties have been the slow growth in trade in agricultural goods relative to manufactures and the probably more stringent nature of the market restrictions encountered by the former.

The order of magnitude of some of these external shocks has been very large by postwar standards. By way of illustration, New Zealand's imported oil bill trebled between 1973 and 1975 and rose again by almost the same proportion between 1979 and 1981 (June years). Although this problem was shared by many countries, few experienced such sharp terms-of-trade fluctuations as New Zealand encountered. The ratio of export to import prices fell by over 40 per cent between the peak and the trough in the 1973-75 period. Moreover, there has been a secular downward movement in the terms of trade, from an index average of close to 100 prior to 1973 to about 80 between that time and 1979, and the latest research now suggests that the long-run underlying average through the 1980s could be as low as 70. In other words, sharp cyclical fluctuations have been superimposed upon a strong downward trend in the terms of trade, thus implying a substantial adjustment problem.

In general terms, after some delay in 1974-75 in recognizing the fundamental nature of the external problem, the policy response[1] was to reduce the level of real domestic activity, particularly in 1976-77, in order to protect the balance of payments. Substantial overseas borrowing was undertaken to facilitate what was argued to be a gradual adjustment process based on the use of monetary and fiscal policy to restrain domestic demand and the use of the exchange rate,[2] export incentives and other export subsidy arrangements to promote an expansion of export volumes. The process was interrupted by a wish to pursue more expansionary policies in the election years of 1978 and 1981, and by the second oil price shock in 1979-80.

The net result of these and other events was that the balance of payments deficit declined from its peak of 13.6 per cent of GDP in 1974-75 to 2.7 per cent of GDP in 1978-79, rising only marginally to just over 3 per cent in 1980-81 despite the second oil shock. An adjustment of this order was not achieved without some sacrifice: there was little real growth in the economy from 1975 to 1980 and unemployment rose to a level that by New Zealand standards was regarded as extremely high (registered unemployed plus those on officially assisted employment represent about 6 per cent of the total labour force). Moreover, inflation has persisted as a serious problem, running at about 15 per cent in mid-1981. The major redeeming features of the prospective economic situation are that export volumes are now expanding at a reasonable rate and a marked pickup in real investment is likely during the 1980s as a result of a series of major new industrial projects which are just getting underway. After a period of virtually no economic growth, it is thus anticipated that a small positive growth rate may be achieved on average over the next few years.

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[1] A more detailed analysis of the domestic policy response is set out in R.S. Deane and R.G. Smith [4].

[2] From late 1973 until mid-1979, when a more flexible exchange rate regime was adopted, the discretionary changes in the pegged rate were only occasional: September 1974, devaluation of 6.2 per cent; August 1975, devaluation 15 per cent; November 1976, devaluation 2.73 per cent; December 1976, revaluation 2 per cent; June 1979, devaluation 5 per cent.

Some interesting questions of more general relevance emerge from the New Zealand experience, such as the appropriateness of the policy mix employed by the New Zealand authorities, the extent of the contribution to the adjustment of discretionary policy and automatic elements originating from the external deficit itself, the speed of adjustment to external shocks, and the length of the lags involved in the adjustment process.[3]

3 TERMS-OF-TRADE SHOCKS AND ALTERNATIVE POLICY RESPONSES

The most important recent contribution to the debate about the impact of external shocks on the New Zealand economy is that by Spencer [15] analyzing the interrelationships among the terms of trade, the external balance and the real exchange rate. Two types of terms-of-trade shock were considered: first, a 10 per cent increase in import prices and, second, a 10 per cent decrease in export prices. In response to each of these shocks three alternative exchange rate strategies were assessed:

---

[3] In the complete version of this paper, a review of the recent empirical research on these questions is presented (Deane and White [5]). The bibliography at the end of this paper lists the relevant works.

(i) a fixed nominal exchange rate;
(ii) a fixed real exchange rate; and
(iii) a 5 per cent real exchange rate depreciation.

The simulated macroeconomic effects generated by the Core model under each of the six alternative scenarios are summarized in Figure 1 (drawn from Spencer's paper) and Figure 2.

For the purpose of the present paper, Spencer's experiments were compared with some simulations designed to assess the effectiveness of a demand-management response, again using the Core model albeit slightly modified and simulated over a more recent period.[4] The policy action chosen for this purpose was a 5 per cent reduction in government non-wage expenditure in response to the same two types of terms-of-trade shock. The results are shown in Figure 3. Before comparing the two sets of results, it may be useful to comment first on the impacts of the two alternative forms of external shock.

---

[4] The period used was 1974(4) to 1979(3), compared with Spencer's 1965(3) to 1970(2). The Core model structure used for the simulation work described in this section, and in the following section, was the "mixed" (Keynesian and new classical) variant described in Spencer and Duggan [16]. The "mixed" nature of the model can perhaps be best appreciated by considering the way in which output and prices are determined. The output equation is based on a new classical specification insofar as long-run output is derived from a (Cobb-Douglas) production function of capital, labour and time, and insofar as unexpected price movements (with price expectations being based on money growth and import prices) cause short-run deviations from the long-run or "normal" level of output. A Keynesian flavour is provided through the inclusion of excess demand terms in the output equation itself as well as in the factor input (employment and investment) equations. The price-of-output equation, on the other hand, is based on a Keynesian cost-plus/excess demand view of price-setting behaviour, but incorporates a new classical influence through the linking of wage rates to expected prices (with price expectations being formed in essentially the same manner as already described).

3.1 Impact of Different Shocks

As Spencer observed, and as Figures 1, 2 and 3 confirm, the model responses are significantly different between the import price increase case and the export price decrease case. With the former, output and employment initially fall relatively more sharply, while so far as the current account balance is concerned, it is an export price decrease that has the greater initial impact. The difference in the current account balance outcomes is, of course, directly related to the fact that a fall in export prices, in addition to having a direct impact on the level of external receipts, results in a fall in export supply which reduces export income and widens the external deficit even further. The reduction in import volumes that occurs consequent to a rise in import prices, on the other hand, serves to offset, at least to some extent, the increase in import payments resulting from the price rise, and the deterioration in the current account balance is correspondingly lessened.

The effects of external price shocks on trade volumes are of course critically dependent on the price elasticities attached to imports and exports. The price elasticities of imports and exports, respectively, in the Core model are given in the table on page 336.

Figure 1

CORE MODEL RESPONSES TO A 10% TERMS OF TRADE DECLINE UNDER THREE ALTERNATIVE EXCHANGE RATE POLICIES

Figures on left-hand side correspond to a 10% import price increase, on the right to a 10% export price decrease. Dynamic multipliers are measured as % deviations from control unless indicated otherwise.

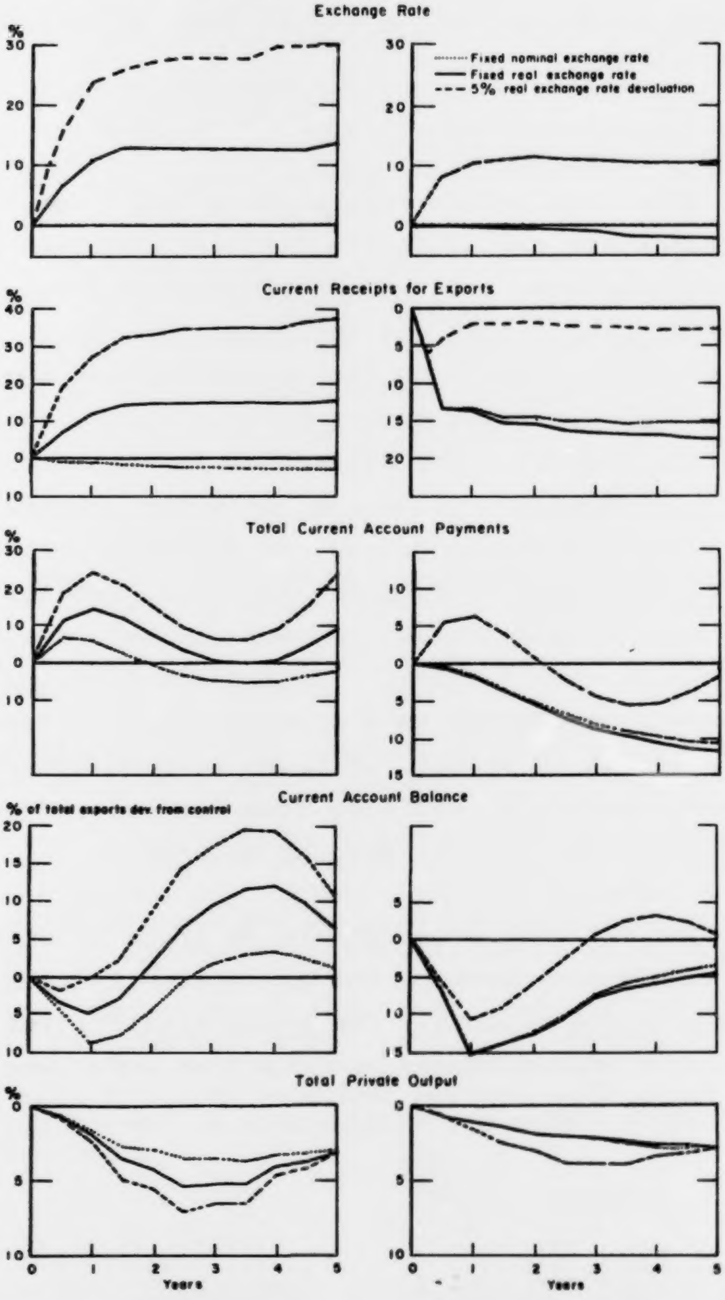


Figure 2

FURTHER RESULTS FROM FIGURE 1 EXPERIMENTS

Figures on left-hand side correspond to a 10% import price increase, on the right to a 10% export price decrease. Dynamic multipliers are measured as % deviations from control unless indicated otherwise.

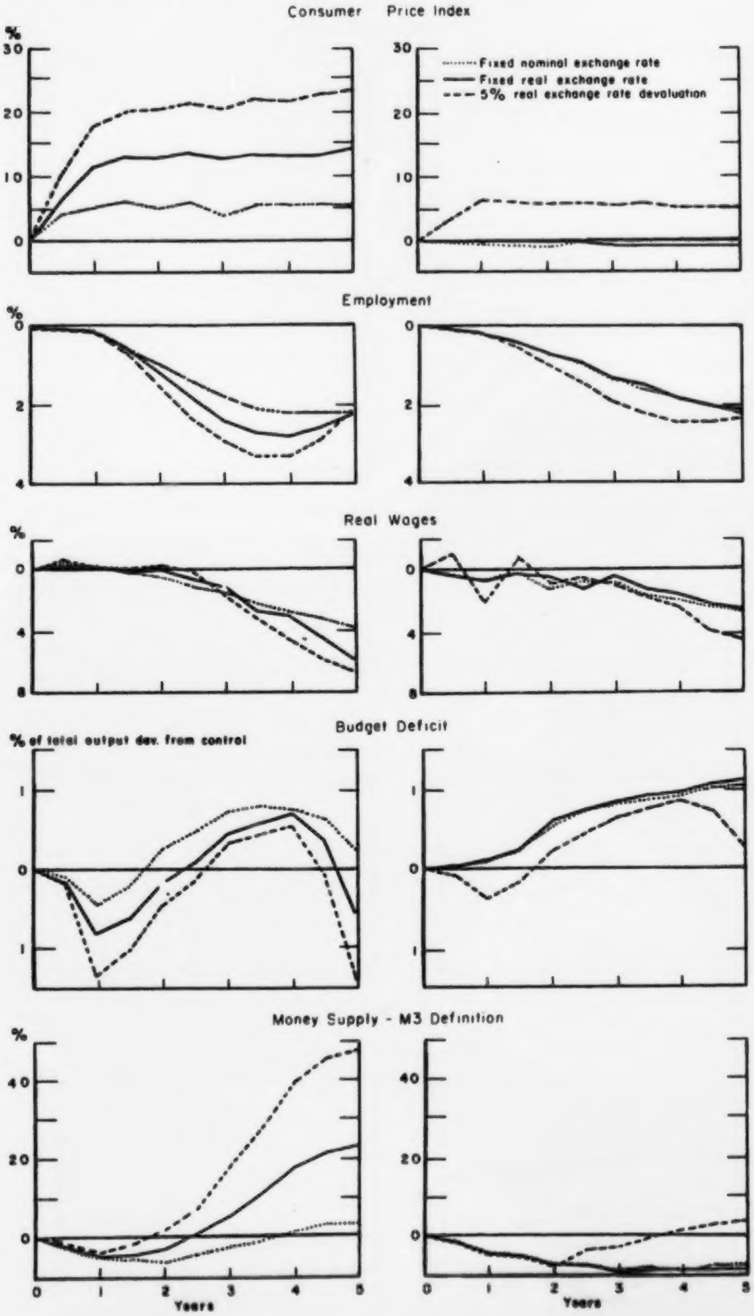


Figure 3

GOVERNMENT EXPENDITURE REDUCTION IN RESPONSE TO EXTERNAL SHOCKS

Figures on left-hand side correspond to a 10% import price increase, on the right to a 10% export price decrease. Dynamic multipliers are measured as % deviations from control unless indicated otherwise.

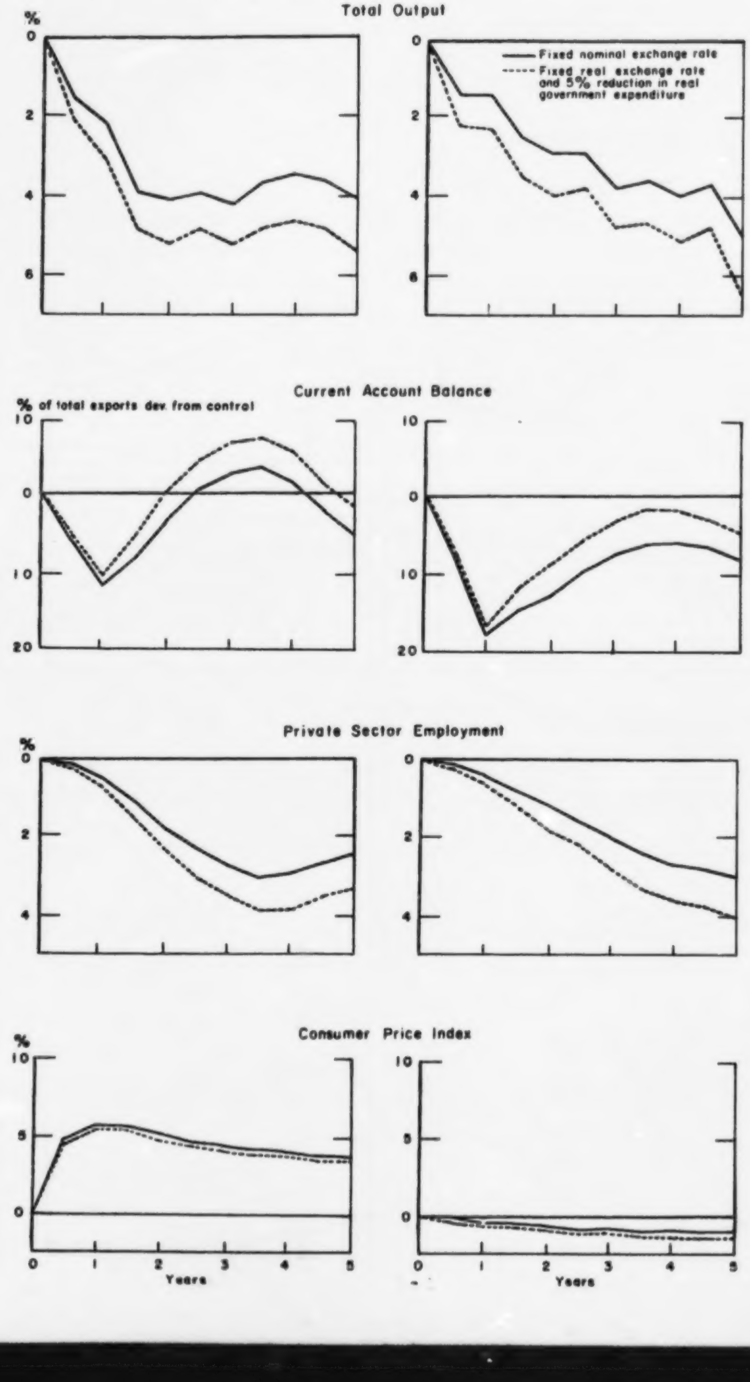
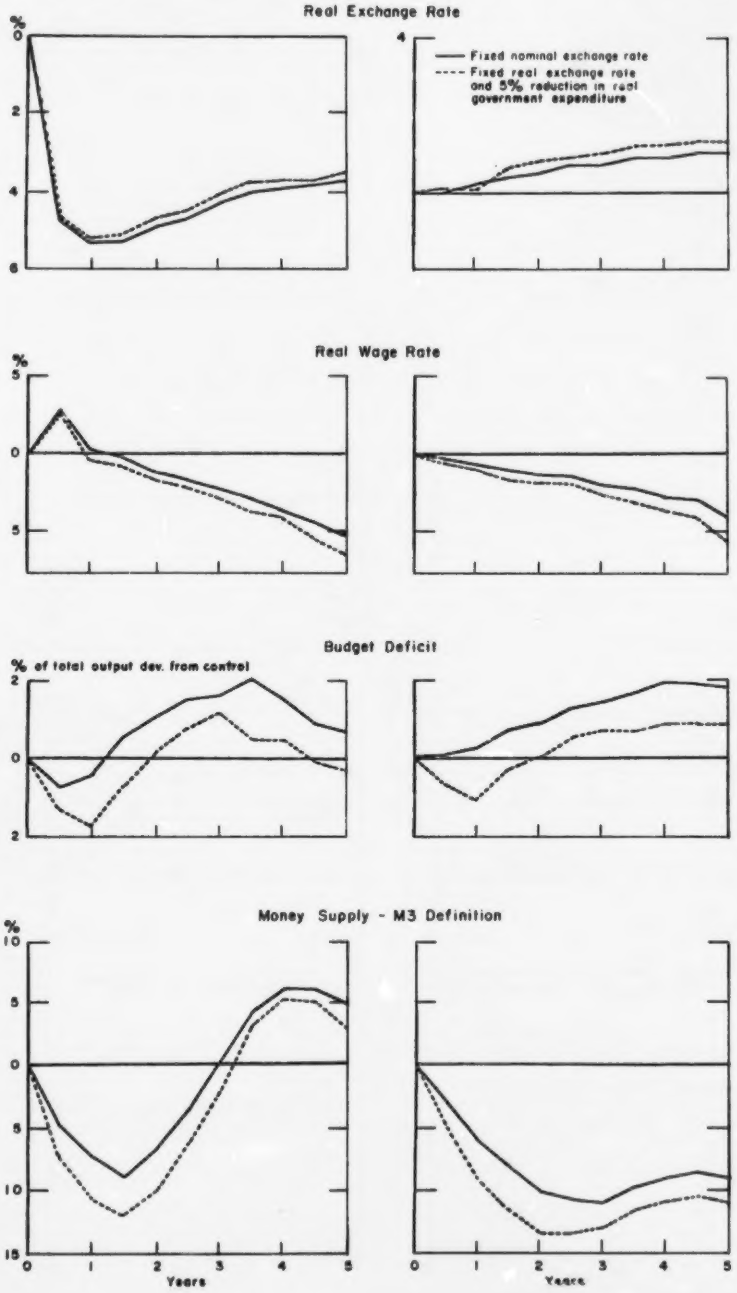


Figure 3 continued

GOVERNMENT EXPENDITURE REDUCTION IN RESPONSE TO EXTERNAL SHOCKS

Figures on left-hand side correspond to a 10% import price increase, on the right to a 10% export price decrease. Dynamic multipliers are measured as % deviations from control unless indicated otherwise.



Real Exchange Rate

Real Wage Rate

Budget Deficit

Money Supply - M3 Definition

Figure 4

INFLATION, CURRENT BALANCE AND OUTPUT RESPONSES TO A 1% INCREASE IN REAL NON-WAGE GOVERNMENT EXPENDITURE - FIXED EXCHANGE RATE

Deviations from control (inflation and current balance responses are additive, output multipliers are proportionate)

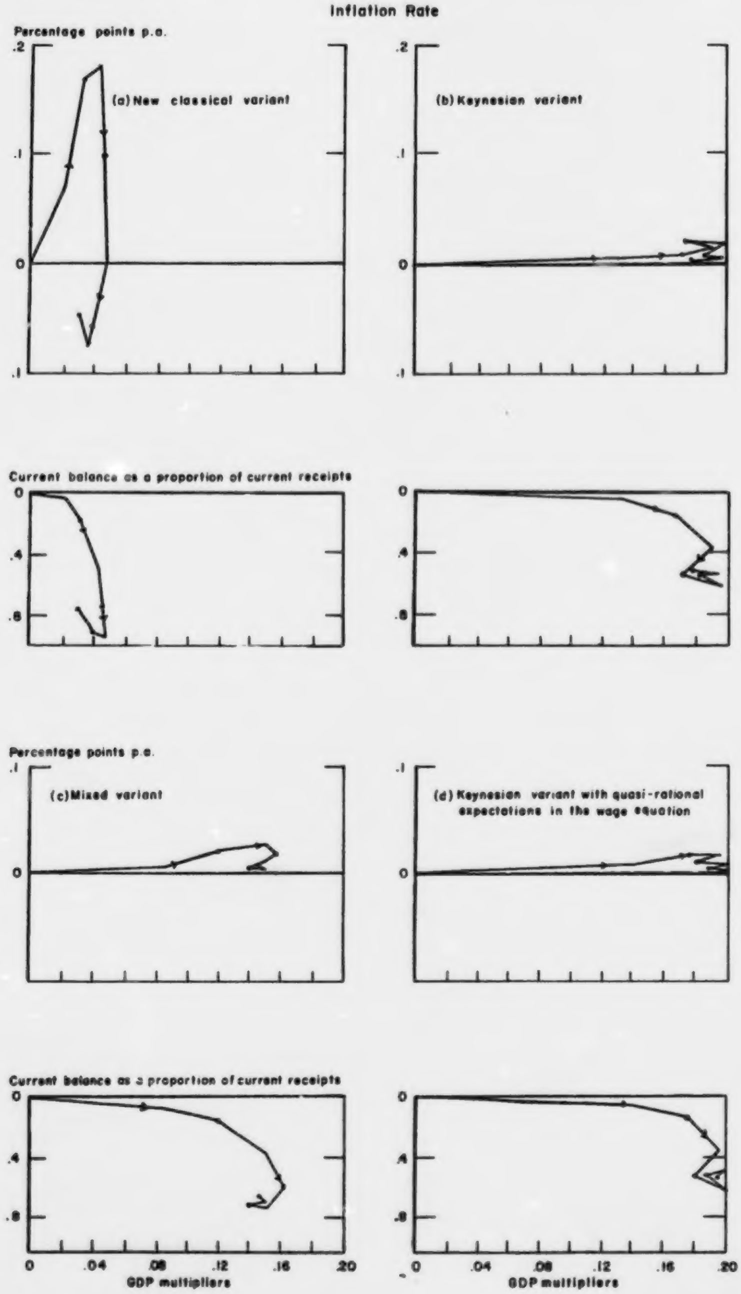
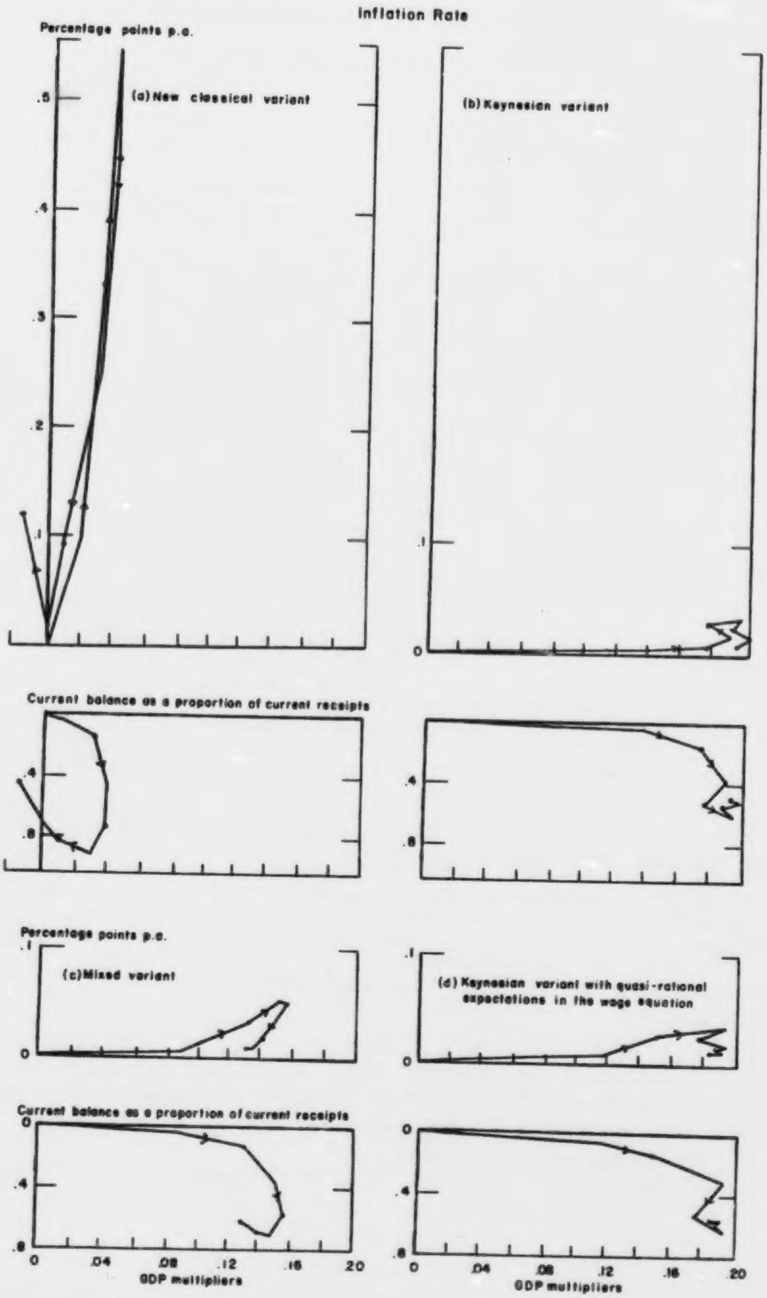


Figure 5

INFLATION, CURRENT BALANCE AND OUTPUT RESPONSES TO A 1% INCREASE IN REAL NON-WAGE GOVERNMENT EXPENDITURE - FLEXIBLE EXCHANGE RATE

Deviations from control (inflation and current balance responses are additive, output multipliers are proportionate)



	Imports		Exports	
	Impact elasticity	Long-run elasticity	Impact elasticity	Long-run elasticity
Spencer's simulations (Figure 1)	-.138	-.387	.349	.619
Deane/White simulations (Figure 2)	-.138	-.387	.393	.740

In view of the fact that O'Brien [11] found the long-run elasticities for New Zealand in both cases average around 0.5, it would appear the Core model may possibly overstate the impact of export price shocks and understate the impact of import price shocks on the respective trade flows.[5] However, in terms of the differences between the impacts of the two types of external price shock on the current account balance, as illustrated in Figures 1 and 3, this is probably of little consequence since in both cases the tendency would be for the current account balance deterioration to be overstated.

With respect to the adjustment paths for output and employment under the two types of price shock, the explanation for the relatively sharp downturn in domestic activity consequent to an import price shock (compared with an export price shock) is to be found in the nature of the linkages between the price and real sectors in the model; domestic expenditure prices being significantly influenced by import prices but not by export prices. For instance, an import price increase has an immediate and significant influence on

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5. However it should be noted that O'Brien points out that the more recent estimates of long-run import price elasticities yield values around -0.4, i.e., not dissimilar from those above.

consumer prices which results in lower real personal disposable incomes, a lower real money supply (in addition to the contraction caused by the external deficit), and thus a lower level of real demand. Moreover, the domestic inflation generated by the import price shock causes taxes to rise, at least for a period, by an amount sufficient to more than offset any reduction in tax revenues as a consequence of reduced real output and income levels. Given that within the model certain categories of government expenditure are fixed in nominal terms, the fiscal deficit is thereby initially reduced, further tightening monetary conditions. A rising domestic price level also implies an appreciating real exchange rate, and thus the softening of the impact of the initial import price increase on the current account balance coming from reduced import volumes is likely to be at least in part offset, which once again has monetary implications. Import prices are also an important determinant of the cost of capital, which in turn influences investment, and ultimately production capacity levels.

The linkages between export prices and the domestic economy are comparatively much more limited. The significantly greater size of the external deficit that arises is not fully translated into tightening monetary conditions owing, in the absence of any inflation-generated additional taxes, to a widening budget deficit. Also, the model structure does not capture the direct income effects of an export price reduction. This stems from the way in which income is determined from the output side, i.e., by way of an output-income identity, and the fact that the price of output equation does not include export prices as an explanatory variable. The latter is an acknowledged deficiency within the model, and in a revised version of the Core model currently being constructed on the basis of new national accounts data, export prices have been included as a determinant of the output price deflator. Incidentally the new Core model will also contain an equation for farmers' income (a large part of exporters' income) which is currently included in the residual item in the output-income identity, namely company and other persons' income.

Given that an import price increase induces a sharper contraction in output and activity than an export price decrease, it is to be expected that the current account deficit and output will subsequently recover more quickly. This is borne out in Figures 1 and 2. The current account reaches a position of balance after 2 1/2 years, and output and employment stabilize with signs of a slow recovery after about 3 to 3 1/2 years. Indeed the prospects for employment recovery must be judged as being reasonably encouraging given that real factor incomes (as measured by the ratio of output prices to expenditure prices) fall relative to control and that real wage rates facing employers (as measured by wage rates deflated by output prices), after increasing in the first year, fall throughout the simulation period. By comparison, in the export price decrease case, the current account is still in deficit and output and employment are still following a downward adjustment path at the end of the five-year simulation period and, while real wages have fallen, it is not by so much as under an import price shock.

3.2 Policy Response: Devaluation

Given the different responses to the alternative types of external price shock, the question to be considered is whether the policy responses to such price shocks should similarly differ. This section considers the use of the exchange rate as a policy instrument while the next section assesses the use of tighter domestic policy by way of reduced government spending.

The main points to be drawn from Spencer's alternative exchange rate rule simulations are as follows:

1. When the terms of trade deteriorated as a result of an increase in import prices, a rapid real exchange rate depreciation quickly adjusted the external position (the current account moved into surplus after one year), but at the expense of an even sharper contraction in output and employment and a substantially higher rate of inflation. The latter point is clearly illustrated by Spencer's experiment involving the maintenance of a 5 per cent real devaluation. By the end of the simulation period, the price level is more than 25 per cent above its pre-shock level, compared with 5 per cent in the absence of a policy response.

2. If there were no exchange rate response to the import price increase, the automatic adjustment mechanisms operating through aggregate demand still caused the initial deficit to be removed but after about two and a half years. The important proviso was that aggregate demand policy should not be accommodating.

3. Quite different results accrued when the terms-of-trade reduction came from a decline in export prices. Since export prices have little impact on domestic prices within the model, the adjustment paths for the fixed nominal and fixed real exchange rate strategies were similar. But in these cases the automatic adjustment mechanism was much slower and after five years the current account was still in deficit and activity was still falling slowly.

4. The 5 per cent real devaluation strategy speeded up the adjustment process in response to the export price decline, with the initial overseas deficit being removed within three years. Moreover, since the nominal exchange rate depreciation required was only about 10 per cent, the increase in domestic prices was of the order of 5 per cent, and while the implications for output and employment were adverse compared with no policy response, they were not intolerably so.

5. A feature of the results worth noting, particularly with respect to the import price shock in combination with a real exchange rate strategy, is that domestic inflation and therefore the nominal exchange rate stabilized after about two years despite the rapid rate of monetary growth that occurs from that time. (See left-hand side of Figure 2.) Some light can be cast on this result by referring to Figures 4 and 5 which summarize the results of the work by Spencer and Duggan on alternative versions of the Reserve Bank's Core model. The model version used to generate the simulation results depicted in Figures 1 to 3 was the "mixed" Keynesian and new classical variant, the price, output and balance of payments multiplier properties of which are depicted in Part C (the bottom left-hand corner) of Figures 4 and 5. This variant, in terms of its structure, corresponds reasonably closely with the new classical variant (part A of Figures 4 and 5), except that the direct link between rationally formed price expectations and the actual price of output featured in the new classical version is cut, and that excess demand is included, in addition to unexpected price movements, as a variable explaining short-run fluctuations in output about its "normal" or long-run level. As can be seen from Figures 4 and 5, these two departures from the new classical model specification result in the "mixed" model taking on multiplier properties that correspond more closely with those of the Keynesian version, where output is essentially demand-determined and prices are determined in a cost-plus manner (the role of price expectations being restricted to the inclusion of adaptively formed expectations in the wage equation). It is instructive to note in particular that the money-financed fiscal injection in the "mixed" (and Keynesian) version generates much stronger output and balance of payments responses than price responses; relating this observation back to the exchange rate and fiscal policy experiments reported in Figures 1 to 3, we can see that the strong monetary growth that occurs from the second year onwards is reflected in a deteriorating external current account position after 3 1/2 years and a trend in output back towards control after 2 1/2 years. Clearly quite different results would have been obtained however if, say, the new classical variant of the Core model had been used in these experiments.

6. The above results imply that the exchange rate, if it is to be employed in response to import price shocks, should be used with particular caution. This means that monetary

and fiscal policies need to be adjusted in such a way as to support the exchange rate position adopted. In particular, the monetary growth implied by the improvement in the external current account balance needs to be neutralized if the improvement is to be sustained. The most obvious way to achieve this is to ensure that the monetary injections arising from any budget deficit are reduced by at least as much as the external accounts improve. In this regard, the experiments show that this does not always occur automatically. For instance, with the import price increase/ 5 per cent real devaluation experiment, the budget deficit in year 2 1/2 to 3 1/2 is above control, at a time when the external current account surplus is reaching a peak and monetary growth as a consequence is particularly strong (see Figure 2).

7. This work shows that it is not obvious what proportion of the shift to a new equilibrium position should be attempted through exchange rate changes, and what proportion should be allowed to occur of its own accord through the automatic adjustment mechanism. Also, for a country with a managed exchange rate, Spencer's research suggests that knowledge of the real exchange rate level corresponding to an equilibrium one under today's policy and external conditions may not necessarily resolve the problem of how to set today's exchange rate. While it is obviously important to know in which direction the real exchange rate should move, the nature of an initial terms-of-trade shock and the current stance of fiscal/monetary policies may well have more relevance for actual exchange rate policy than the exact size of any current disequilibrium.

3.3 Policy Response: Reduced Government Expenditure

The other policy approach to be considered when addressing a terms-of-trade shock is domestic demand management, through fiscal and/or monetary policies. The results given by the Core model from reducing government expenditure in the face of both types of terms-of-trade shock are summarized in Figure 3. Any gain here is achieved almost entirely by reducing real incomes, output and expenditure; price responses in the Core model to changes in demand and monetary conditions tend to be rather slow. This is reflected in the following table which shows that the demand-management approach results in less improvement in the current balance for a given reduction in output than under an exchange rate option.

PERCENTAGE POINT IMPROVEMENT* IN CURRENT BALANCE (AS PROPORTION OF TOTAL CURRENT RECEIPTS) PER 1 PER CENT OUTPUT REDUCTION AFTER THREE YEARS

	Import price increase	Export price decrease
5% real devaluation case	6.0	6.8
5% cut in government expenditure case	3.8	4.5

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* Compared with automatic adjustment (i.e., no policy response).

4 SOME HISTORICAL SIMULATIONS WITH DIFFERENT ADJUSTMENT POLICIES

Two general points that emerge from the simulation results discussed in the preceding section are that there is a strong interrelationship between the real exchange rate and the external balance, and that real exchange rate adjustments are more readily achieved under a flexible nominal exchange rate regime than through demand-management policies aimed at the domestic price level. Against this background, it is interesting to note that in mid-1979, the method of managing the New Zealand exchange rate was changed from a fixed (but occasionally adjustable) rate system to what might be described as a "crawling peg", the rate of adjustment being primarily determined by the degree of divergence between movements in domestic prices and overseas prices. That is, the nominal exchange rate has been adjusted so as to maintain a fixed real rate (although this does not preclude additional adjustments to the real rate from time to time, adjustments that are nevertheless likely to be built into the frequent small changes that are now made to the rate).

The reasons for the change of exchange rate regime were essentially twofold. First, there was concern about maintaining the profitability of the exporting sector in the face of a domestic rate of inflation that for most of the second half of the 1970s was higher than that experienced by New Zealand's trading partners. Second, there was a concern that occasional large discrete changes to the exchange rate led to more uncertainty for those engaged in external trade and, because of the size of the shocks involved, perhaps aggravated domestic inflation to a greater extent than would be the case with smaller more frequent changes in the exchange rate.[6]

With a view to assessing both the effectiveness and the consequences of the present method of setting the New Zealand exchange rate, three Core model simulation experiments were undertaken (in a historical context[7] with the terms-of-trade shocks being taken as those that actually occurred) with the real exchange rate held at its 1975(4) level.[8] This in

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6. A full description of the present New Zealand exchange rate policy is contained in R.S. Deane [3].

7. That is, the control solution was made to replicate history. This was achieved by the loading back of all single equation residuals.

8. 1975(4) was chosen partly because by this time the full implications of the 1973 oil shock and its permanent nature were apparent, and partly because it was a period when the real exchange rate peaked, immediately after the major devaluation of August 1975.

effect amounted to the implementation of the present exchange rate regime shortly after the first oil shock rather than after the second oil shock as in fact was the case.

The specific experiments carried out were as follows:

(i) The exchange rate was adjusted each quarter so as to maintain the real exchange rate at its 1975(4) level.

(ii) Exchange rate policy was operated as in (i), and non-salary and wage government expenditure was cut by 5 per cent in 1975(4) and subsequent quarters.

(iii) Exchange rate policy was operated as in (i), and the government security interest rate was increased by 3 percentage points in 1975(4) and subsequent quarters.

The results are summarized in the following table. The principal features are as follows:

1. By maintaining the real exchange rate at the 1975(4) level, a more rapid adjustment to the external imbalance (a move into current account surplus within three years) was achieved and at a limited cost in terms of output and employment.

2. There is a substantial worsening of inflation for several years, although in the final year the inflation rate is below control (history). The latter is probably a reflection of the 5 per cent real devaluation that actually occurred in mid-1979; with the experimental real exchange rate remaining fixed over the same period, albeit at a lower level, the rate of inflation is somewhat lower than the actual.

3. The choices facing the policymaker come down to accepting an overvalued real exchange rate and a slower adjustment to the external imbalance (if not a further deterioration, particularly if monetary and fiscal policies are accommodating) in combination with a lower rate of inflation, or a more rapid adjustment at the cost of additional inflation. However, if the former option is selected and it turns out that a continuing high real

exchange rate makes the adjustment unacceptably slow, then it is inevitable that in time steps will need to be taken to devalue the real exchange rate. In this case in all probability the inflation will not have been avoided, it will only have been delayed, and at the expense of an external deficit and associated ongoing debt-servicing costs. This would imply taking the import price increases first, and the devaluation-generated inflation later. But whether there is any benefit in spreading the inflation over a longer period so as to justify the costs is a difficult question to answer. The model cannot help in this regard, given that inflation itself has no direct real effects. On the other hand, there is some international experience which suggests that the costs of accelerated adjustment may be warranted.[9]

4. Given the potential for monetary growth to occur following an improvement in the balance of payments, two further experiments were conducted where monetary and fiscal shocks were imposed in addition to the real exchange rate being held at its 1975(4) level. In the government expenditure reduction case there is a significant additional fall in output and employment, only a very slight improvement with respect to inflation, but (associated with the extent of the output reduction) an additional contribution to the external current account improvement of some significance. So far as monetary growth is concerned, there is initially some decline, but by the end of the period the additional improvement in the overseas current balance more than offsets the reduced budget deficit, and the monetary aggregates are growing more strongly than previously. This highlights the need for domestic policy instruments to be monitored and adjusted if excessive monetary expansion is to be avoided.

5. The third experiment involved the use of monetary policy in combination with the fixed real exchange rate rule. The results are broadly similar to those obtained with the fiscal policy instrument. Monetary growth initially slows, but then accelerates, partly because of the improvement in the external accounts, and also as a result

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[9] See W.E. Norton, "The Erosion of Economic Stability: The International Environment." Paper presented at the 50th Congress of ANZAAS, Adelaide, 12th - 16th May, 1980, especially page 34.

RESULTS OF CORE MODEL POLICY SIMULATIONS

Part A: Objectives	1976(3)	1977(3)	1978(3)	1979(3)
	%	%	%	%
Output^1 (compared with actual)				
(a) Fixed real exchange rate^8	+ 0.5	- 0.3	- 0.4	- 0.3
(b) (a) with 5% cut in government expenditure	- 0.4	- 1.4	- 1.4	- 1.5
(c) (a) with 3% increase in government security interest rate	+ 0.5	- 1.5	- 1.4	- 1.5
Employment^2 (compared with actual)				
(a) Fixed real exchange rate^8	+ 0.1	- 0.2	- 0.6	- 0.8
(b) (a) with 5% cut in government expenditure	- 0.1	- 0.6	- 1.3	- 1.5
(c) (a) with 3% increase in government security interest rate	+ 0.1	- 0.3	- 1.0	- 1.2
Inflation^3 (actual rate)	17.2	14.4	11.0	15.3
(a) Fixed real exchange rate^8	22.8	19.8	18.1	12.8
(b) (a) with 5% cut in government expenditure	22.5	19.5	18.0	12.8
(c) (a) with 3% increase in government security interest rate	22.7	19.7	17.9	12.7
External Balance^4 (actual)	-21.5	-11.9	-12.0	- 9.6
(a) Fixed real exchange rate^8	-18.3	- 5.8	+ 1.8	+ 3.7
(b) (a) with 5% cut in government expenditure	-17.6	- 3.3	+ 4.8	+ 6.0
(c) (a) with 3% increase in government security interest rate	-18.3	- 5.2	+ 3.5	+ 5.5

RESULTS OF CORE MODEL POLICY SIMULATIONS

Part B: Instruments	1976(3)	1977(3)	1978(3)	1979(3)
	%	%	%	%
Exchange Rate Changes[5] **(actual)**	-	0.7	-	6.6
(a) Fixed real exchange rate[8]	11.5	8.6	10.0	1.0
(b) (a) with 5% cut in government expenditure	11.2	8.4	9.9	1.0
(c) (a) with 3% increase in government security interest rate	11.4	8.6	9.9	1.0
Budget Deficit[6] **(actual)**	7.4	3.3	8.0	9.5
(a) Fixed real exchange rate[8]	7.2	2.3	6.4	8.4
(b) (a) with 5% cut in government expenditure	6.0	1.4	5.5	7.5
(c) (a) with 3% increase in government security interest rate	7.2	2.3	6.7	8.9
Money Supply[7] **(actual)**	17.6	13.4	19.5	18.9
(a) Fixed real exchange rate[8]	19.6	17.9	33.4	35.2
(b) (a) with 5% cut in government expenditure	16.3	17.8	34.3	35.5
(c) (a) with 3% increase in government security interest rate	17.1	18.5	36.9	38.7

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1. Total real public and private sector output, i.e., real GDP proxy.
2. Private sector employment.
3. Four-quarter change in consumer price index.
4. Current account balance as a proportion of total current receipts.
5. Expressed as percentage change in the rate compared with a year previously.
6. Expressed as a percentage of the GDP proxy.
7. Annual change in M3 (the broad money supply).
8. Fixed at 1975(4) real value.

of private sector interest rates adjusting to the increased government security rate. The impact on output is essentially the same as for the tighter fiscal policy, although employment levels fall a little less.

5 SOME OBSERVATIONS

In common with many other countries, the New Zealand economy was subject to unusually severe external shocks during the 1970s. Although the policy response to these events involved the use of both exchange rate changes and domestic demand management, the pace of adjustment was generally a gradual one and is still incomplete as far as the external deficit is concerned. The price of adjustment has been high: negligible real growth on average since the mid-1970s, a very sharp rise in unemployment and persistent high inflation.

The empirical research on the impact of external shocks on the economy and the policy responses to them raises several implications for the adjustment process and the mix of policies that may bear upon it.

First, different shocks may affect the economy in significantly different ways. Similarly, identical initial policy responses tested within the framework of econometric models give different results when used in the face of different kinds of shocks. This complicates policy management: it is necessary not only to predict and/or assess the likely magnitude of shocks but also to take into account their specific nature. While economic theory suggests and the applied research confirms that there are powerful built-in automatic non-policy responses to external shocks, which will of their own accord resolve balance of payments problems arising from such shocks, it remains that the time periods involved vary widely depending on the type of shock and the nature of the prevailing exchange rate regime.

Policy packages involving a real devaluation appear to accelerate substantially the adjustment process for either type of external price shock as compared with the maintenance of either a fixed real rate or a fixed nominal rate. Although the empirical research thus confirms the potential usefulness of the exchange rate as a policy instrument directed at the balance of payments, there are complex and possibly costly trade-offs with respect to the other major economic objectives -- output, employment and inflation. Inflation is a particular difficulty with respect to shocks originating from import price increases -- so severe in fact as to raise doubts about the usefulness of real exchange rate devaluations in this case, particularly if they are not accompanied by anti-inflationary domestic policies.

This however is not an argument for continuous fine-tuning of the intermediate targets of policy. Instead, it confirms the now widely advocated case for a policy strategy involving a more consistent matching of instruments with objectives over a long enough time period for the objectives to have an improved chance of being achieved. At least in the case of New Zealand, the variability of the domestic policy settings appears at times to have aggravated rather than ameliorated the adjustment process. At the same time, the inflation/output trade-off appears to have deteriorated markedly.

To conclude, therefore, it seems clear that there is no painless solution to the problems arising from external shocks. The resumption of a reasonable rate of sustainable economic growth in New Zealand is thus likely to be an elusive goal unless there is a willingness to incur the necessary short-run costs.

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EXTERNAL SHOCKS: THEIR IMPACT ON A SMALL OPEN ECONOMY AND POLICY REACTION -- THE HONG KONG EXPERIENCE

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1 INTRODUCTION

Recent economic history has been characterized by the number and severity of the economic shocks that have been inflicted on the international economic system. Because of this, the ability of most economies to achieve sustained and stable economic growth has been heavily dependent on their ability to absorb or to adjust to these shocks.

This paper, which builds on the description of Hong Kong's economy and economic policy given at the last Conference,[1] discusses the experience of the Hong Kong economy in the face of these shocks. It further considers how far the somewhat unusual underlying approach to economic policymaking employed by the Hong Kong Government has been vindicated over this period.

2 THE OPEN NATURE OF THE HONG KONG ECONOMY

Hong Kong has one of the most externally dependent economies in the world. About 90 per cent of manufacturing output is eventually exported and the value of domestic exports of goods is equivalent to about 64 per cent of the GDP. Similarly, on the supply side, Hong Kong is almost entirely lacking in natural resources and is thus heavily dependent on imported inputs of raw materials, semi-manufactures, fuel and capital equipment for its manufacturing and other industries; in addition, most of its foodstuffs and consumer goods are imported. Retained imports of goods are equivalent to 77 per cent of GDP. Hong Kong is also an important entrepôt with re-exports equivalent to 28 per cent of GDP. Over-all, the total value of Hong Kong's visible trading transactions in 1980 (i.e., domestic exports, re-exports and imports) was equivalent to just under twice the value of GDP.

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[1] J. Yam, "The Problems in Constructing an Econometric Model for Hong Kong." In Proceedings of the Fourth Pacific Basin Central Bank Conference on Econometric Modelling, Tokyo: 1979.

The above ratios are very high by international standards and in most economies would be associated with individual cities or regions rather than with the economy as a whole. The relatively small size of the economy and its very considerable dependence on external factors, particularly world trading conditions, are thus the major operative constraints within which economic policy in Hong Kong has to be formulated.

Because it is so externally oriented, the Hong Kong economy is exposed to any shocks arising from shifts in the world trading environment, and such shocks can have major consequences for the stability of the growth path of the economy. Supply-side shocks, such as increases in oil prices, although they have a direct effect on prices in Hong Kong, including export prices, tend to affect Hong Kong's competitors in the same way so that the main effect they have on the economy's growth is through their effect on the growth rate of world demand in general and the growth rate of demand for Hong Kong's exports in particular. Demand-side shocks, such as shifts towards greater protectionism in Hong Kong's markets, have a direct effect on the growth rate of exports and thus of the economy in the short run, and may, in the long run, also require some industrial restructuring. Thus, in both situations, the main emphasis when considering the impact of external shocks is their effect on the demand for Hong Kong's exports.

Experience over the 1960s and 1970s suggests that the growth rate of GDP in any particular year is primarily dependent on the previous year's growth rate of exports and the growth rate of exports in the year in question. However, this relationship may have been altering over time.

Although the growth rate of the Hong Kong economy is now very largely dependent on the ability of its manufacturers to export their products, the original reason for the development of Hong Kong was its suitability as an entrepôt for trading with China. However, this trade had hardly been re-established after World War II when, in the early 1950s, the United Nations imposed an embargo on trade with China. This represented a very major external shock to the Hong Kong economy. That the economy has survived that and subsequent lesser shocks and, indeed, has generally enjoyed a period of high, sustained growth since then is by itself sufficient justification for studying the reaction to these shocks in terms of the economy and of economic policy.

3 POLICY BASED ON AUTOMATIC ADJUSTMENT MECHANISM

Faced with the loss of the major source of foreign exchange earnings and of economic growth, and given the economic circumstances of Hong Kong, including a rapid growth of population,[2] in the early 1950s the emphasis of the economy and of government economic policy towards it had to be

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[2] Population:

	mn	% p.a.		mn	% p.a.
1945 (est)	0.6		1966	3.6	3.6
1951 (est)	2.0	22.2	1971	4.0	2.2
1956	2.6	5.3	1976	4.4	1.9
1961	3.2	4.0	1981	5.1	2.9

directed towards restructuring the economy in such a way as to provide a means of generating foreign exchange earnings and employment. The need to find alternative sources of economic growth quickly is still reflected in the central role in the government's economic policy given to the achievement of economic growth.[3] This need for speed, combined with the abundant though relatively unskilled labour force and the very limited land available, resulted in the emphasis being on relatively labour-intensive light manufacturing, especially textiles and clothing. This is a continuing feature of the economy.

From the beginning, the government took the view that the open nature of the Hong Kong economy meant that the achievement of growth, and of growth with stability, would be dependent on forces largely outside the government's control. Because of this the government's economic policy was basically one of positive non-interventionism. This derived from the view that in the circumstances of Hong Kong it was generally futile and probably damaging to the growth rate of the economy for the government to attempt to plan the allocation of the resources available to the private sector and to frustrate the operation of market forces.[4] As a result, the government has taken the view that it should not normally intervene in

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3. The continuing emphasis on the growth rate of the economy as the major concern of the Hong Kong Government's economic policy arises partly from the necessity to provide still for a rapidly growing population (average growth rate, 1971-81, 2.4 per cent p.a., 1978-81, 3.8 per cent p.a.) and partly from a belief that this is the best way to increase the well-being of the community.

4. The same situation does not face those responsible for policies in relatively closed economies, or at least not so clearly, for in such economies failure to maintain

the economy and that it should intervene only when the benefits of so doing very clearly outweigh the costs, long-term as well as short-term. Further, considerable benefit is seen as deriving from the maintenance of a stable and consistent fiscal and institutional environment in which the private sector can operate.

The argument is that, in a small open economy, because the market forces impinging on it are particularly difficult to predict let alone control, and because the potential leakages from any government-induced changes in expenditure are very large, there is little scope for the short-term management of the economy so as to maintain income and employment levels over the course of cyclical movements in the economy's external trading performance. Further, given the importance of foreign trade and investment to the economy, any protectionist measures on the part of the government which involve abandoning, even in part, its commitment to free trade and to the free flow of funds across the exchanges[5] might provoke retaliatory action and result in lower real incomes. In any case, because the economy is small, its imports of any particular items are normally too small a part of world trade in that item for the threat of protectionism to carry much weight. Under such circumstances, the ability of the economy

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external competitiveness can be masked by, and at least partly absorbed in, the relatively large sectors of such economies that are not concerned with external transactions.

[5] There are no restrictions or tariffs on imports, although there are specific taxes on tobacco products, alcoholic beverages, automotive hydrocarbon oils and private vehicles. There are no exchange controls and the government intervenes in the foreign exchange market only very infrequently.

to adjust by itself to changes in external circumstances and to achieve balanced growth without any substantial government intervention is of critical importance.

Pure economic theory suggests that in no economy can disequilibrium be sustained indefinitely and counteracting forces will sooner or later be generated to effect an adjustment. Under a fixed exchange rate regime with a flexible cost/price structure, theory states the adjustment that takes place is that deficits and surpluses in the balance of payments are eliminated primarily through changes in costs and prices brought about by changes in the money supply.[6] Under a floating exchange rate regime, as Hong Kong has at present, the economy is seen as adjusting to deficits or surpluses in the balance of payments primarily through changes in the exchange rate; that is, in the case of a deficit on the balance of payments, a depreciation of the exchange rate leads to an improvement in the competitiveness of its exports and to imports becoming more expensive.

In an economy as small and as externally oriented as Hong Kong, where there are few domestically produced items with significant local value-added that can be substituted for imports, the main emphasis has to be on the improved competitiveness of exports, and some commentators have cast doubt on whether a floating exchange rate regime is appropriate in these circumstances. In Hong Kong, the question has particular relevance since, because the imported input proportion of most exports is relatively high, some of the gains from a depreciation of the exchange rate in terms of reductions in foreign currency prices of exports will be offset by increases in the Hong Kong dollar prices of imported inputs. However, as long as the exports have a significant Hong Kong value-added content, the depreciation should, ceteris paribus, improve the international competitiveness of Hong Kong's exports;[7] however, the extent of the depreciation required to restore equilibrium may well be greater in Hong Kong's case than in the case of an economy that is less dependent on imported inputs.

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[6] Rigidities in the cost/price structure result in changes in the level of output playing a more prominent role.

If the floating exchange rate regime is combined with an absence of exchange controls and the financial sector of the economy involved is well integrated into the world financial market, the situation can be complicated by the effect of international capital movements, but the essential outcome remains the same. A self-equilibrating mechanism exists that will result in an economy automatically adjusting to correct for any disequilibrating pressures so that the ultimate result depends solely on real changes/shifts in demand and supply conditions.

Given the above, why is it that economies can so rarely be said to be in equilibrium and why do governments so often seek to take steps to ensure that an economy does not follow the path it would take if left to itself? An explanation for

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7. The main exceptions to this would be if:
   (i) the depreciation in terms of the currencies of the countries from which Hong Kong imports was greater than that in terms of the currencies of the countries to which Hong Kong exports. For example, in the twelve months up to the end of August 1981, the depreciation in terms of the import-weighted exchange rate was 5 per cent and in terms of the export-weighted exchange rate it was 7 per cent.
   (ii) the depreciation induced an increase in the price of domestic inputs sufficient to negate the gain in export competitiveness made possible by the depreciation.

these two situations can be found in the fact that although theory says that an economy if left to itself will adjust automatically to correct for an imbalance caused by an external shock -- or any other sort of shock -- it does not say how long the adjustment will take nor has it a great deal to say about the path the economy will follow in the process of adjusting.

If adjustment is a long-term process or if it involves matters getting worse before they get better, a government may well feel that there must be a better way and attempt to find it. Furthermore, if the adjustment process takes time, other factors will almost invariably impinge on the economy while it is adjusting to any given imbalance. These additional factors will set in train adjustment processes of their own -- reinforcing, dampening or even reversing the original one.

Among the factors that affect the speed and efficiency of the adjustment mechanism are the institutional factors -- many of which are controlled or influenced by government. There is some evidence that shifts in the visible trade balance take place more rapidly as a result of changes in the exchange rate (the operative mechanism under a floating exchange rate regime) than as a result of changes in the money supply (the operative mechanism under a fixed exchange rate regime). However, as a consequence, such shifts are sharper and inevitably create a higher degree of uncertainty within the domestic economy.

Furthermore, institutional factors may affect the flexibility of the cost/price structure and hence the efficiency of the exchange rate adjustment mechanism. For instance, the benefits of a depreciation of the exchange value of the Hong Kong dollar would be lost if, at the same time as the Hong Kong dollar cost of imports increased, the other elements in the cost of production also increased. Since in Hong Kong these other cost components comprise mostly wages and profits, what is needed for a depreciation to be fully effective in restoring the competitiveness of domestic exports is for labour costs and/or profit margins to be flexible downwards, at least in real terms. Thanks to the lack of institutional factors that limit the operation of market forces -- a result of deliberate government policy in this respect -- the Hong Kong economy has a reasonably flexible cost/price structure.

Historically, the flexibility of Hong Kong's cost/price structure has largely been a consequence of three interrelated factors. First, the determination of wages has been largely a function of the freely operating forces of supply and demand; there are few large employers and the trade union movement is relatively weak. Hence, money wages are relatively less rigid downwards than elsewhere. Second, the supply of labour is relatively wage elastic. However, this may be changing. Third, the labour force is mobile, both geographically, and among and within industry sectors. This last factor is aided by the compact nature of the economy.

Experience in Hong Kong and elsewhere suggests that, as the over-all standard of living improves, workers' attitudes change. Also, as industries tend to use more capital-intensive and/or skill-intensive techniques, the labour force may become less mobile. If this were to happen here the result would be a less flexible cost/price structure. At present in Hong Kong, in the downswing phase of an economic cycle, if there is a need for wages to deflate in order for competitiveness to be regained, this deflation process does occur. But in the mature phase of the upswing, typically the labour market is tight, and the domestic sector tends to bid labour away from the export sector. Further, given that the growth rate of domestic demand tends to bear a lagged relationship to the growth rate of exports, after a period of rapid export growth domestic demand continues to grow rapidly even after the growth rate of exports has fallen. As a result, the extent to which reductions in labour costs, on the one hand, and a squeezing of profit margins, on the other, assist the adjustment process is reduced at least initially.

Because of its belief that the smallness and openness of the Hong Kong economy inevitably limits the scope of effective beneficial government intervention, and because a floating exchange rate regime does provide a mechanism for the economy to adjust automatically to external shocks, the government has felt justified in continuing to pursue its policy of positive non-interventionism. However, recognition by the government of possible shortcomings in the automatic adjustment process in terms of the speed, efficiency and acceptability of the adjustment, has led to certain positive steps being taken. The purpose of such intervention has been, on the one hand, to facilitate and expedite the adjustment process (rather than to reverse it) if it becomes evident that there is a need to do so and on the other hand, to ensure that the adjustment mechanism operates as efficiently as possible.

For example, the government can facilitate and expedite the adjustment process by altering the growth rate (and the pattern) of expenditure by the public sector. But as import leakages are such that the multiplier effects are small, and with the small relative size of the public sector, any increase or decrease in the over-all growth rate of public expenditure will have a comparatively limited effect on the economy as a whole. However, in terms of the over-all pressure of demand and, in particular, with regard to the distribution of resources among and within particular sectors of the economy, speeding up or slowing down the growth rate of government expenditure can, under certain circumstances, exert a favourable influence.[8]

In certain markets, notably that for the output of the building and construction industry, the public sector's share of demand is large. In such markets, the government recognizes that it must ensure that the growth rate of its demand is not such as to result in total demand exceeding the capacity of the industry to supply. Between 1976 and 1978 the public sector share of a growing total demand for the output of the building and construction industry rose from 41.6 per cent to 50.9 per cent. There were clear signs in the increases in the tender prices received by the government for construction contracts that the level of demand had outstripped the capacity of the industry.[9] In 1979 the public sector reduced its demand on the output of the industry but it was not until 1980 that any moderation in the rate of price increase was discernible. Subsequently, the government has taken care to moderate the growth rate of its demand and, combined with the dampening effect of high interest rates on the rate of growth of private demand, this has resulted in the

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[8] For example, in 1980 the public sector's share of demand on the output of the building and construction industry was about 50 per cent. In such markets the government recognizes a need to ensure that its demand does not result in total demand for the industry's output exceeding its ability to supply at current prices.

[9]

	1976	1977	1978	1979	1980	1976-80
Tender price index	6.7	19.7	21.4	34.2	22.9	20.6
Construction labour and materials cost index	4.1	9.5	14.8	36.4	17.1	15.9

industry's prices increasing at a rate more in line with prices generally in 1981.

The government also attempts to ensure that the adjustment mechanism operates as efficiently as possible by influencing or altering the environment within which the economy adjusts. This can be achieved through regulating and exercising influence on certain markets, through taking care to ensure that policy decisions do not necessarily inhibit the flexibility of the domestic cost/price structure, and through timely decisions such as allowing the Hong Kong dollar to float.

Apart from the above, the government believes that the interests of the economy are best served if it seeks:

(i) to provide a stable institutional and fiscal environment within which the private sector can operate with a low level of direct fiscal incentives to business matched by a low tax burden; and

(ii) to concentrate on facilitating economic growth through infrastructural expenditure on such things as transportation links, land formation and education.

4 RECENT EXPERIENCE

The impact of external forces on exports, domestic demand, exchange rates, prices, etc. can be discerned from an examination of the recent growth path of the economy. Given the dynamic nature of the Hong Kong economy, equilibrium and disequilibrium are best defined in terms of relative growth rates.

Although world trading conditions in 1978 were roughly the same as in 1977, the growth rate of domestic exports picked up to 10.4 per cent, probably as a response to the price effects of the depreciation of the effective exchange value of the Hong Kong dollar. But with the rapid growth rate of domestic demand persisting at 17.0 per cent (partly attributable to the acceleration of the growth rate of public sector demand), and as available resources were by then fully employed, imports were sucked in at a rapid rate, leading to a further widening of the visible trade "gap" and a further depreciation of the effective exchange value of the Hong Kong dollar by 12.6 per cent. The growth rate of total final demand, at 15.2 per cent, was well in excess of the growth rate of GDP, at 10.3 per cent. It was obvious that the growth rate of domestic demand was such as to slow down, if not to frustrate, the operation of the adjustment mechanism by preventing the internal cost/price structure from deflating, necessitating a very sharp depreciation of the exchange value of the Hong Kong dollar. There was thus a situation of internal and external disequilibrium which was taking an unusually long time to correct itself. (For this purpose, internal equilibrium is defined as the growth rate of final demand being the same as that of final output, i.e., GDP, and external equilibrium as the growth rate of exports being the same as the growth rate of imports.)

In 1979, the growth rate of domestic exports of goods accelerated to 16.5 per cent, faster than the growth rate of domestic demand at 7.4 per cent (the decrease in the growth rate of domestic demand was partly the result of the slowing down of the growth rate of public sector demand and partly the result of other measures to constrain the growth rate of private sector domestic demand). The difference between the growth rate of total final demand, at 12 per cent, and that of GDP at 8.6 per cent, narrowed. The visible trade "gap" also narrowed and the exchange value of the Hong Kong dollar began to appreciate again towards the end of the year, after depreciating by 5.6 per cent during the first seven months of the year. However, with world inflation increasing and the lagged price effects of previous changes in the exchange rate working through the system, the rate of increase in prices accelerated.

In 1980, despite unfavourable conditions in its main markets, the Hong Kong economy achieved balanced growth. The growth rate of domestic demand, at 12.7 per cent, was only slightly higher than the growth rate of domestic exports at 10.9 per cent. Both were equally important in contributing to economic growth in 1980. The growth rate of exports of goods was slightly less than that of imports of goods. Similarly, the increase in export prices was slightly less than that of imports. Also, exports of services grew more slowly than imports of services. As a consequence, the effective exchange value of the Hong Kong dollar fell by 5 per cent.

In 1981, despite continuing unfavourable conditions in Hong Kong's markets, the prospect is for a growth rate of GDP in real terms of 10 per cent. Although the growth rate of exports of goods is holding up well, the trade deficit is continuing to widen and the effective exchange rate to fall, by a further 3.5 per cent in the first eight months of the year.

Over-all, in terms of economic growth, the economy has been very successful. Despite quite wide variations in the growth rate of world trade, the growth rates of Hong Kong's domestic exports and of its GDP, at 14 per cent per annum and 11 per cent per annum, respectively, over the past five years, have remained high. Further, the over-all growth path has remained remarkably stable despite quite sharp variations over time in the growth rates of different components, and quite wide divergences between the growth rates of components at different points in time.

On this evidence, the government's belief in its policy of positive non-interventionism appears vindicated. Although it is not possible to determine how much credit for this growth performance is attributable to the government's economic policy, it is hard to believe that different policies would have resulted in a much better performance.

However, there have been a number of developments that may bring into question whether it will continue to be in the best interests of the economy to rely on a non-interventionist approach. The reasons for raising this question include:

(i) a fear that the adaptability of the economy and the flexibility of the cost/price structure are being eroded;

(ii) the lagged reaction of some domestic prices to changes in import prices; and

(iii) the growth in the money supply and the tendency for inflation to increase over time without any corresponding increase in the pressure of demand.

A necessary development in the economy if the pace of economic growth is to be maintained is for the products manufactured to become increasingly of better quality and more sophisticated, and for the processes employed to become more productive, which almost certainly means more technologically advanced. For this to happen, the labour force will have to become increasingly better trained and educated.

To the extent that a better trained and educated labour force is more able to learn new jobs and skills, this improvement enhances the economy's ability to respond to changing circumstances and improves the efficiency with which the adjustment mechanism is likely to react to external shocks. However, to the extent that the skills required to use more sophisticated machinery are more specialized and industry-specific, the efficiency of the adjustment mechanism is impaired. This is particularly the case where the skills required take time to acquire and are developed by experience. In such circumstances, employers, instead of rapidly releasing workers additional to their immediate requirements, are likely to retain them, even if they are underemployed, because of the cost and problems of finding new workers later. Workers thus retained are denied to other employers and labour supply bottlenecks may develop earlier than otherwise.[10]

The rapid increases in personal incomes that accompany a rapid growth rate of the GDP are bringing about changes in demand patterns. Although higher incomes lead to a greater propensity to buy imported goods rather than domestically produced goods, they may also lead to a greater propensity to buy services, which will typically have a low import content. The net effect of this on the import propensity is not clear.

Perhaps more importantly for the adjustment process, with rapid increases in personal incomes there are signs that the labour force is putting a higher premium on leisure. In other words, individual preferences between income and leisure appear to be shifting in favour of the latter, making the supply of labour less elastic in its response to increases in wage rates, thus slowing down the operation of the adjustment mechanism. However, the recent slowdown in the rates of increase in manufacturing and construction wages in real terms, associated with the increase in the supply of labour through immigration and the increase in unemployment, has been accompanied by an increase in the labour force participation rate. This suggests that some form of ratchet mechanism may be at work with regard to the response of the supply of labour to changes in real income.

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[10] Although extensive severance pay and other similar schemes are less in Hong Kong than in many other economies, they are being extended gradually, introducing an increasing rigidity in the labour market.

For the adjustment mechanism to work quickly and efficiently, changes in one set of variables must feed quickly through the system so as to affect economic behaviour in the required manner. Periods of rapid increases in import prices have tended to be followed, with lags of varying lengths, by rapid increases in consumer prices.[11]

Interestingly, the data show that the rate of increase in export prices is generally in line with that of import prices, with a relatively small lag.[12]

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[11] Rates of increase in prices (% p.a.)

	1976	1977	1978	1979	1980	1976-80
CPI	3.4	5.8	5.9	11.6	15.5	8.4
Import unit value index	4.0	4.5	6.3	17.9	9.3	8.3
Export unit value index	10.3	2.3	5.4	17.8	9.9	8.9

[12] The recent exceptions were in 1974, when domestic export prices rose less (+21.2%) than import prices (+30.9%), presumably because profit margins were under pressure because of the recession in world trade, and in 1976, when domestic export prices rose more (+10.3%) than import prices (+4.0%), presumably as profit margins increased in response to the very large growth rate of export demand in volume terms (+29.5%).

The fact that both export and consumer prices rise broadly in line with import prices suggests that one of the possible benefits claimed for operating under a floating exchange rate regime -- i.e., the ability of an economy to insulate itself from imported inflation -- has not been enjoyed by Hong Kong. Theory suggests that this would occur only if inappropriate fiscal policies, stimulative or accommodating monetary policies, or a combination of both had been pursued.

As far as the government's over-all fiscal stance is concerned, the Hong Kong Government has in recent years consistently run budget surpluses on an increasing scale.[13] Thus, in purely fiscal policy terms the government's stance has been increasingly anti-inflationary.[14] Further, the disposal of these surpluses has been such as to minimize the extent to which they are fed back into the monetary system.[15]

With respect to the economy as a whole, although GDP has been growing rapidly it has not recently been growing

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[13]

	1976-77	1977-78	1978-79	1979-80	1980-81
Surplus (HK$mn)	917	1,225	1,486	2,975	9,323
Surplus as % of GDP	1.8	2.1	2.1	3.5	8.7

Note: Data in terms of General Revenue Account

[14] Much of the increase in government revenue has been derived from land sales and it has been argued by some commentators that inclusion of such proceeds overstates the true extent of the surplus.

[15] The bulk of the surpluses are either transferred across the exchanges out of Hong Kong and invested in overseas currency assets or held as short-term deposits with the Hong Kong banking system where they are treated as deposits by a bank and subject to a 100% liquid assets requirement.

sufficiently rapidly to absorb the growth in the labour force.[16] As a result, unemployment has risen suggesting that there is no over-all excess demand in the economy. However, at the same time, prices have been rising quite rapidly; in the case of consumer prices, increasingly so. This combination of rapidly rising prices and gradually increasing unemployment suggests, prima facie, that the source of the inflation lies in excessive growth of the money supply.

As regards monetary policy, the government has no means of controlling the growth rate of the money supply except through the impact on the rate of credit creation of changes in interest rates -- the one monetary instrument in the government's armoury that can be used to affect economic events in Hong Kong. As long as lending institutions are willing to make available sufficient credit to finance ever higher levels of expenditure and as long as individuals and businesses are sufficiently confident of being able to recoup, with interest at current rates, through higher prices and incomes the outlays so financed, the restraint on the growth rate of real expenditure that would otherwise occur as a result of a rise in import prices and of surpluses generated by government, will be largely negated.

The rapid increase in credit creation in Hong Kong in recent years indicates that this willingness on the part of

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[16]

(% p.a.)	1976	1977	1978	1979	1980	1976-80
GDP	18.8	10.2	10.3	8.6	10.1	11.5
GDP deflator	7.8	4.1	5.7	14.2	12.5	8.8
CPI (A)	3.4	5.8	5.9	11.6	15.5	8.4
Labour force*	-3.1	1.9	5.7	6.8	8.3	3.8
Employed labour force*	1.6	2.5	7.2	6.1	7.2	4.9

* As at September

lenders has been matched by confidence on the part of borrowers.[17] Moreover, the sustained high growth rate of GDP and the sustained increase in prices, particularly of those items most commonly purchased with the help of credit, such as property, have shown that this confidence has, at any rate so far, been well founded. To the extent that the credit creation process has sustained, through the growth rate of domestic demand, the growth rate of the economy and financed the increasing inflation, the adjustment process has been frustrated or, at least, delayed.

The situation described above has been used by some commentators in Hong Kong as evidence that the automatic adjustment mechanism is no longer operative and that it was fatally damaged by the loss of automatic control over the money supply occasioned by the switch from a fixed to a floating exchange rate regime in November 1974. This seems too extreme a viewpoint, given that if either of the preconditions for the continuation of a rapid growth rate of credit expansion given above were to cease to apply, the monetary accommodation of the present undesirably high level of inflation and the undue dependence of the economy's growth rate on domestic demand would be corrected. Nevertheless, the possibility that the adjustment may now be operating unacceptably slowly has led to a renewed interest in finding a

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[17] Growth rate of money supply (% p.a.)

	1976	1977	1978	1979	1980	1976-80
M1	23.1	28.7	23.2	3.7	15.7	18.6
M2	21.0	20.7	25.6	13.2	28.7	21.7
Loans and advances by banks to customers in Hong Kong	17.9	25.0	43.3	34.0	52.6	34.0

means of government intervention to control the rate of credit creation.

At present, as explained, the only instrument available is the level of interest rates. This has been raised progressively to unprecedentedly high levels in 1981. However, although present lending rates are high in real terms they are not so high, or at least have not been so high until recently, in relation to the level of capital appreciation that has been available in, for example, the property market. This has meant that one major user of credit has not been deterred by high interest rates from borrowing at a time when other credit users, such as manufacturers and traders, are finding that high interest rates threaten the viability of their businesses. It is because the present level of interest rates is undoubtedly having painful consequences for important sectors of the economy and their labour forces that the government is loath to see further increases, even though it accepts that the situation in terms simply of inflation might demand them.

However, devising methods of controlling the rate of credit creation without further increases in the level of interest rates, without risking inflicting serious damage to the growth potential of the economy and without other undesirable side effects is not proving easy. First, there is no public sector debt in Hong Kong, so there is no scope for open market operations. Second, with no public sector debt and no central bank as such, there is no obvious way to neutralize part of the resources of banks and deposit-taking companies: compulsory reserves, whatever their apparent form, would seemingly end up in the banking system, thus defeating the object of the exercise, or alternatively, go offshore and so further weaken the Hong Kong dollar.

The third and perhaps strongest argument against mechanical monetary policy measures is that they could not be totally effective in restraining the growth of credit made available to the economy. This is because, with no system of exchange control in Hong Kong, if a credit-worthy customer in Hong Kong is unable to borrow locally because of local credit restrictions, he can probably acquire funds offshore, perhaps through a branch in South East Asia of his own bank in Hong Kong, and the funds he acquires can be brought in to spend in Hong Kong. There may be a cost in terms of the exchange risk, but credit is available.

Furthermore, there is the problem of measuring and interpreting the money flows within the economy. The peculiarly open nature of the Hong Kong economy, with very large flows across the exchanges relative to the size of the economy, makes this particularly difficult. At the same time it is important for the government to be sure that any case for intervention is based on an accurate interpretation of the relevant data.

Until recently, all monetary statistics were derived as a by-product of the prudential supervision of the banking sector and were in some respects unsatisfactory for the purpose of analyzing monetary flows in terms of their implications for the economy.[18] Various steps have recently been taken to improve the situation, but the various series are as yet too new for any firm conclusions to be drawn. It is, however, clear that the situation is more complex than had been realized before.

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[18] For example, loans and advances made by banks to customers in Hong Kong included loans by banks to other quasi-bank lending institutions but did not include loans and advances by such institutions, and included some credit granted to Hong Kong borrowers for use outside Hong Kong, but excluded credit granted outside Hong Kong for use in Hong Kong.

Only 84 per cent of the money supply on its widest definition, M3, was denominated in Hong Kong dollars at the end of July 1981, down from 87 per cent at the end of last year. The bulk of the foreign currency elements in the money supply are denominated in U.S. dollars. Thus, some of the apparent growth rate of M3 over the period derives from the depreciation of the Hong Kong dollar relative to the U.S. dollar, rather than from a greater amount of credit creation.

However, even now the statistics do not reveal, for example, what proportion of the locally held foreign currency deposits are locally owned and are likely, at some point, to be switched into Hong Kong dollars to be spent locally, and what proportion are owned by people living outside Hong Kong and deposited in Hong Kong's monetary system only temporarily before being transferred to a more permanent home elsewhere.

The above problems arise because, as the new statistics clearly demonstrate, Hong Kong's monetary system is as open as its trading sector. Hong Kong in the last decade or so has become an entrepôt in money as well as in merchandise, and it is no longer appropriate to regard its monetary statistics as reflecting only what is going on within the Hong Kong economy. Given this, it is not clear which measure of the money supply -- total M3 or HK$M3 -- should be used when attempting to analyze the relationship between the growth in the money supply and developments in the economy.

In the first seven months of 1981, total M3 grew at an annual rate of some 28 per cent while HK$M3 grew at an annual rate of 22 per cent. Both growth rates are substantially lower than the rate recorded for 1980 on the old basis at almost 40 per cent. Given that 22 per cent is roughly the growth rate of money GDP expected for Hong Kong in 1981, a money supply growth rate of 22 per cent would appear to imply much less of a warning about a possible future acceleration in the rate of inflation than if a 28 per cent growth rate were taken as the appropriate rate.

On the other hand, some commentators would no doubt argue that rather than the growth rate of M3, however defined, the growth rate of transactions balances is more relevant to the analysis of the relationship between the growth rate of the money supply and the economy. In the Hong Kong context, the best measure of transactions balances is probably M1 plus savings deposits, M1-B. In contrast with the growth rates of the two measures of M3, in the first seven months of 1981, M1-B and HK$M1-B grew at annual rates of 4 per cent and 3 per cent respectively. Taken at their face value, these figures suggest that whatever problems Hong Kong faces, excess growth in the money supply is not one of them.

DISCUSSION

In the discussion on the paper by Deane and White, Jung Soo Lee noted that the reaction of domestic prices to an increase in import prices seems to be strong in the New Zealand model compared to the other models presented at the Conference -- a 10 per cent increase causes domestic prices to rise by 5 per cent. Real wages behave oddly: increasing during the first one or two years after the shock then decreasing, whereas one might expect a pattern such that real wage losses would be caused by the price increase early on, with some reversal later as substitution towards labour from energy as factors of production takes place. The contractionary effect of devaluation on output is a result paralleled in the Korean model but is nevertheless controversial. Bruce White explained the large impact on the CPI and the behaviour of real wages as arising from responses to expected inflation, allowing that the strength of the CPI effect may be an overestimate.

Anne McGuirk considered that Alan McLean had raised a number of important issues in his analysis of the Hong Kong experience: the role of government demand-management and development strategy; and policies of major industrial countries with respect to trade and monetary policy that impinge on newly industrialized countries. There now seems to be a consensus against the fine-tuning of demand-management policies and in favour of the establishment of a stable framework within which market participants can act. Furthermore, export-oriented growth strategies as exemplified by Hong Kong, seem to yield success. Protectionism and excessive reliance on restrictive monetary policy in the industrial countries adversely affect both the trade and financing prospects of developing countries.

Another issue concerns the exchange rate regime. McLean's evidence suggesting that Hong Kong's exports are not very sensitive to cycles in industrial countries would indicate the validity of the small country model in which the country can sell as much as it can produce at world prices. In this situation a floating rate has very little advantage over a pegged rate. John Helliwell took up this point and argued that McLean's description of the Hong Kong monetary sector, in which residents feel free to use foreign money in their domestic transactions, is close to the theoretical case of perfect currency substitutability. The logical implication, in the extreme, is that there is no role for monetary policy and no determinate value for the currency. In more practical terms this would mean that monetary policy would have little effectiveness and that there is a danger of an unstable exchange value for the Hong Kong dollar.

4 SUPPLY RESPONSE TO RELATIVE PRICES

INCREASED NATURAL RESOURCE PRICES
AND THE SUPPLY OF
CANADIAN NATURAL RESOURCE OUTPUT AND EXPORTS

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The views expressed in this paper are those of the author and no responsibility for them should be attributed to the Bank of Canada. The author would like to thank Kim Acheson for valuable research assistance and Kevin Clinton, John Conder, Chuck Freedman and Paul Masson for useful comments on an earlier draft.

1 INTRODUCTION

This paper is concerned with the effect on the supply of Canadian non-agricultural non-energy natural resource exports of the increased world price of natural resources (in terms of the price of world manufactured goods) and the depreciation of the Canadian dollar from late 1976 to early 1979. These events had profound effects on the Canadian economy as a whole which would require a complete econometric model to trace. Although in principle such a simulation could be performed with the Bank of Canada's RDXF model, the absence of a production sector for the output of natural resource products would prove to be a significant drawback. Indeed, the behaviour of the supply of natural resources in response to increased prices has been perhaps a neglected topic. Other natural resource topics have received considerable attention. The use of raw materials in the production of manufactured output has been dealt with by Bruno and Sachs (1979); the macroeconomic effect of increased raw materials prices (when raw materials are an imported intermediate input) has been dealt with by Findlay and Rodriguez (1977), Buiter (1978) and Katseli-Papefstratiou and Marion (1980); various authors have paid attention to the inflationary effect and Freedman (1979) has estimated the impact of increased Canadian terms of trade (which has come primarily from an increased price of raw materials in terms of manufactured goods (Longworth (1980)) on the external value of the Canadian dollar.

As noted above, this paper will discuss the supply of Canadian non-agricultural non-energy natural resource exports. Section 2 reviews the output and export performance of Canadian export-based natural resource industries from 1971 to 1980. Several approaches that might be taken to model the output and exports of these industries are set out in Section 3 and examined empirically in Section 4. The major channel of longer run supply response, increased capital investment, is examined in Section 5 where an annual investment model is estimated for the 1963-80 period. Section 6 concludes the paper.

2 CANADIAN EXPORT-BASED NATURAL RESOURCE INDUSTRIES: 1971 to 1980

Outside of agriculture, fishing and energy-related industries,[1] there are four major resource-based Canadian industrial categories which may be classed as export-oriented: mining -- excluding oil and gas; wood products; paper and allied products; and primary metals. These industries have some 50 per cent of their shipments bound for export markets. The aggregate trade surplus of this four-industry grouping, which will be referred to as export-based resource industries, was $19.0 billion in 1980, compared with an over-all merchandise trade surplus of only $7.8 billion.

The price of output and exports of export-based resource industries rose much more rapidly than the GNE deflator or normal unit labour costs in private business in the 1971-80 period (see Figure 1). The increase in the relative price is most pronounced in the periods of the 1973-74 and 1978-79 commodity booms and the 1977-78 depreciation. Although the output and exports of this grouping grew over the 10-year period (Figure 3), the growth was much less than for the

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1. Agriculture is omitted from this study because of the large random effect of climate. Fishing and energy-related industries are omitted because of the important influence on them of government regulation.

Figure 1

RELATIVE PRICE OF EXPORT-BASED RESOURCE OUTPUT

(1971=100)

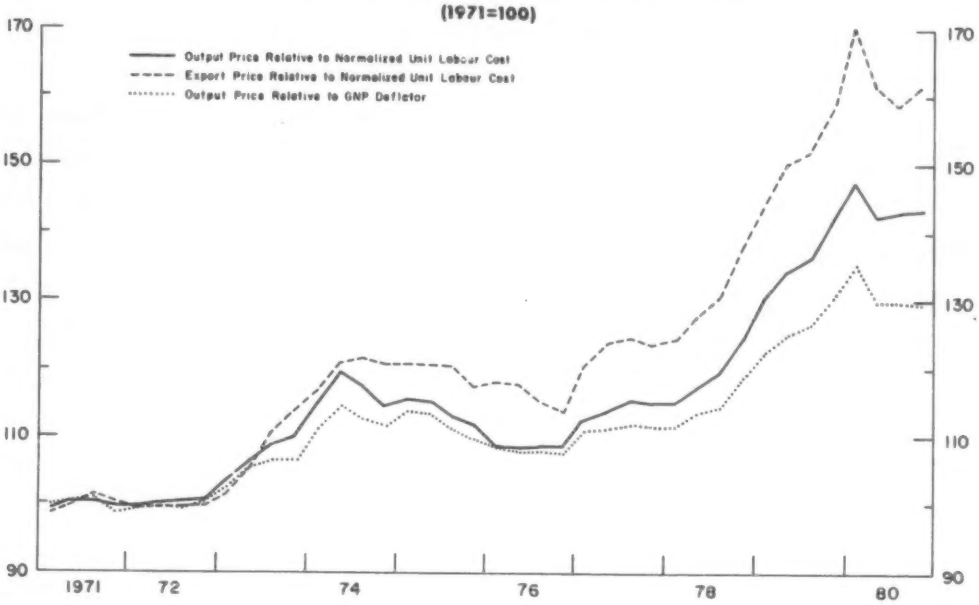


Figure 2

RATIO: OUTPUT OF EXPORT-BASED RESOURCE INDUSTRIES TO TOTAL OUTPUT

(1971=100)

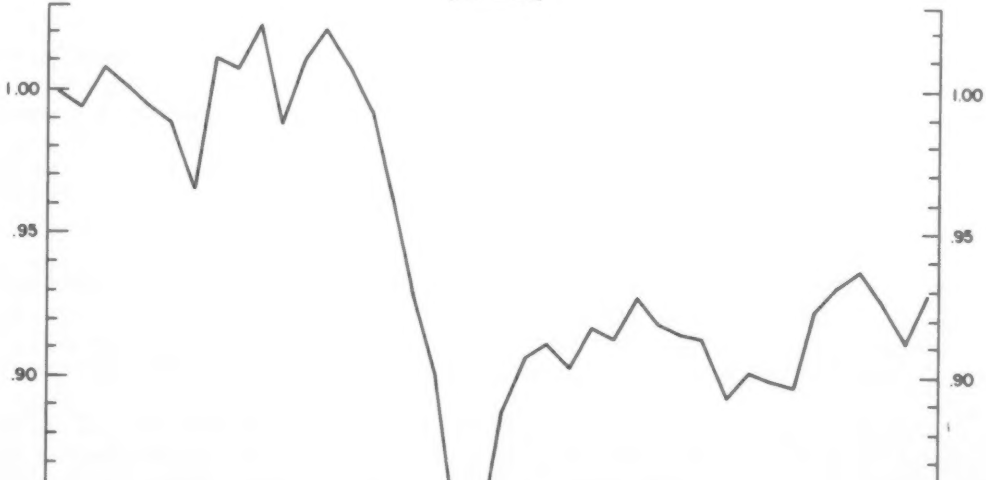


Figure 3

OUTPUT AND EXPORTS OF EXPORT-BASED RESOURCE INDUSTRIES

(1971=100)

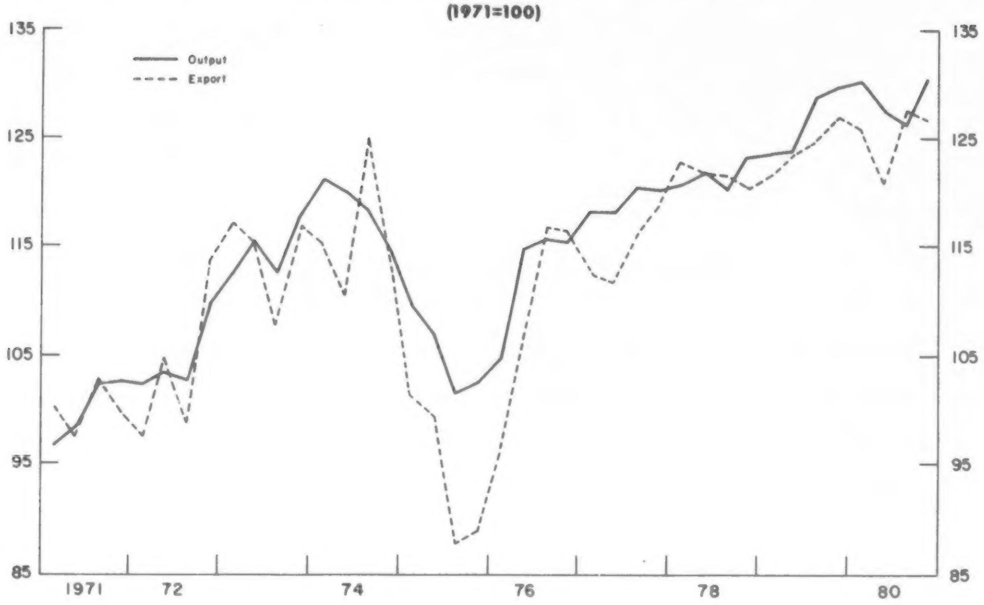
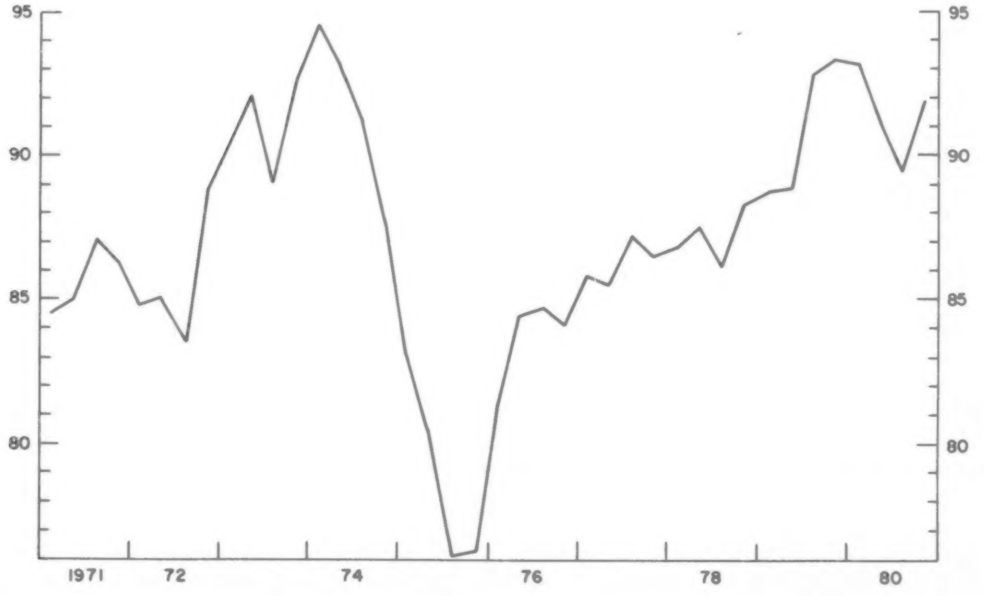


Figure 4

CAPACITY UTILIZATION IN EXPORT-BASED RESOURCE INDUSTRIES



Canadian economy as a whole (Figure 2)[2] and the percentage of real domestic product accounted for by this sector fell much more in the 1970s than in the 1960s. Indeed, if one abstracts from the effects of strikes in the forest products industries in the last two quarters of 1975, one has the distinct impression that there was a permanent downward step in the sector's share of output in the middle of the 1970s.

This pattern of behaviour is somewhat puzzling in terms of the absence of the supply response economists usually associate with an increase in relative prices.[3] Furthermore, it has proved difficult (in the context of the Bank of Canada's RDXF model, for example) to measure econometrically a significant supply response of exports or output in either the short or the long run, to the increased relative price of the output. This is particularly surprising in view of the homogeneity across countries in the types of products included in the output of this sector. One would expect that here was a class of products where the law of one price would hold,[4] in which case output could not be demand-determined but would have to be determined by a supply curve or a function

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2. Freedman and Longworth (1980) examined the ratio of output in resource-based industries to output in non-resource-based manufacturing and found that its deviation from trend was not significantly related to the ratio of the price of resources to unit labour cost. Freedman and Longworth (1980) and Longworth (1981) have also examined the ratio of tradeables output to non-tradeables output.

3. However, as John Helliwell pointed out at the Conference, natural resource economists may not be as puzzled. Increasingly scarce resources combined with a very steep long-run marginal cost curve could give such a result.

4. This is as opposed to many groups of finished and semi-finished manufactures where the law of one price has been rejected (see Isard (1977) and Kravis and Lipsey (1971)).

describing the price or output of an oligopolistic industry. Yet Canadian resource exports are often modelled by demand equations.[5]

This paper does not present any definitive solutions to this paradox. Rather, a number of approaches to short-run price and output determination are discussed and estimated and, I believe for the first time, Canadian fixed investment behaviour is examined econometrically in order to discover whether there has been an underlying producer response that is not as yet fully reflected in output and trade flows. I also investigate the possibility of a structural shift in the long-run supply response.

3 THEORETICAL APPROACHES TO SUPPLY, PRICE AND OUTPUT IN THE SHORT RUN

Export behaviour in a number of macroeconomic models is represented by a volume and price equation. The relationship of these equations to demand and supply considerations is not always clear. The purpose of this section is to examine a number of simple structural models of export (or exportable) supply and demand and the various ways to estimate such models. Some emphasis is placed on the interpretation of price equations. Attention is paid to such factors as

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5. Although to some, Canada might be considered a prototype of a small open economy, Appelbaum and Kohli (1979) have shown that (at least some) Canadian exporters are in a significantly monopolistic position with respect to the United States. This may be because of differentiated manufactured goods, or because of the importance of Canadian exports of certain natural resource exports. Longworth (1980) has assumed that it is largely the former, and has modelled Canada as a price-taker for its resource exports.

infinite elasticities, lagged response, inventory practices and imperfect markets. The assumptions necessary to obtain price equations that are not homogeneous of degree one in current prices and costs are examined.

3.1 The Simplest Model

Let the supply of exports (S) be determined by profit maximization given a Cobb-Douglas production function with fixed capital (K) and variable labour inputs, and given (w), the price of labour, and (p), the price of output[6]:

$$\ln S = a + b \ln K + c \ln(p/w) + u_s \tag{1}$$

where u_s is white noise. It is implicitly assumed that no exportables are consumed domestically.

Let the demand for exports (D) be a function of foreign income (Y^f) and the relative price (p/p^f) where p^f is the foreign price:

$$\ln D = d + e \ln Y^f - f \ln (p/p^f) + u_d \tag{2}$$

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[6] If the production function is, in usual notation, $S = aK^{\alpha}L^{\beta}$, maximizing profits $paK^{\alpha}L^{\beta}-rK-wL$ with respect to L gives:

$$\beta paK^{\alpha}L^{\beta-1}-w = 0$$

$$\frac{w}{p} = \beta aK^{\alpha}L^{\beta-1}$$

$$S = aK^{\alpha}L^{\beta} = a^{\frac{1}{1-\beta}}\,\beta^{\frac{\beta}{1-\beta}}\,K^{\frac{\alpha}{1-\beta}}\left(\frac{p}{w}\right)^{\frac{\beta}{1-\beta}}$$

which is of the form $\ln S = a' + b \ln K + c \ln(p/w)$ and such that $b=1$ if $\alpha+\beta=1$ (constant returns to scale).

where u_d is white noise.

The equilibrium condition is

$$\ln S = \ln D \tag{3}$$

Solving equations (1) through (3) gives the reduced-form price and quantity (Q) equations:

$$\ln p = \frac{d-a}{c+f} + \frac{e}{c+f} \ln Y^f - \frac{b}{c+f} \ln K + \frac{c}{c+f} \ln w + \frac{f}{c+f} \ln p^f + \frac{u_d-u_s}{c+f} \tag{4}$$

$$\ln Q = \frac{af+cd}{c+f} + \frac{bf}{c+f} \ln K + \frac{ce}{c+f} \ln Y^f + \frac{cf}{c+f} \ln(p^f/w) + \frac{c}{c+f} u_d + \frac{f}{c+f} u_s \tag{5}$$

There are a number of features of note. Equations (1) and (2) were specified as homogeneous of degree zero in prices in accordance with production and demand theory, respectively. This yields a reduced-form price equation (4) which is homogeneous of degree one in prices and a reduced-form quantity equation (5) which is homogeneous of degree zero in prices. In the price equation, the weights on the price of labour and the foreign price are ratios of the supply elasticity (c) and the demand elasticity (f), respectively, to the sum of the two elasticities. If, as in the case of the constant-cost producer, the price elasticity of supply is infinite ($c \to \infty$), the reduced-form equation for price reduces to p = w and the reduced-form equation for quantity reduces to the demand equation with p set equal to w. Similarly, if, as in the small country case, the price elasticity of demand is infinite ($f \to \infty$), the reduced-form equation for price reduces to $p = p^f$ and the reduced-form equation for quantity reduces to the supply equation with p set equal to p^f. If there are finite price elasticities and the elasticity of supply with respect to capital is one (constant returns to scale) and the income elasticity of demand is also one, then the reduced-form equation for quantity will be homogeneous of degree one in the real variables (K, Y^f) and the weights will depend on the price elasticities. In this case the ratio Y^f/K in the reduced-form price equation can be considered a demand pressure term since $e = b = 1$.

Any two of the four equations (1), (2), (4) and (5) can be estimated to obtain equations that can be solved by price and quantity. If one refers to the four equations as supply, demand, price and quantity, respectively, the six combinations for estimation are:

	Equations	**Comments**
(i)	supply, demand	Structural approach: estimate using simultaneous equations method.
(ii)	supply, price	Must use if price elasticity of demand is infinite (small open economy).
(iii)	demand, price	Must use if price elasticity of supply is infinite; commonly used by Keynesian models.
(iv)	price, quantity	Reduced-form approach.
(v)	supply, quantity	Price determined by supply equation given quantity.

(vi) demand, quantity	Price determined by demand equation given quantity.

3.2 Excess Supply Equations and Excess Demand Equations

The model in Section 3.1 implicitly assumed that there was: (i) no production for domestic consumption; (ii) exogenous foreign production; and (iii) no imports of similar products. If we relax the first two restrictions but continue to assume no imports, the supply of exports becomes an excess supply of exportables equation[7]:

$$S^x = a + bK + c \ln (p/w) - dY + e \ln (p/p^d) + u_s \qquad (6)$$

where domestic demand is a function of income (Y) and relative prices (p/p^d) (where p^d is the domestic price level) and the demand for exports becomes an excess demand equation:

$$D^x = f + gY^f - hY^{ft} - k \ln (p/p^f) + u_d \qquad (7)$$

where foreign supply is postulated to be proportional to foreign trend income (Y^{ft}).[8]

If one equates supply and demand, the reduced-form equations are:

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[7] Excess supply and excess demand must be linear in domestic demand and foreign supply, respectively. Thus, for purposes of exposition, linear functions are assumed.

[8] If data were available, foreign supply could be specified as in equation (1).

$$\ln p = \frac{f-a}{c+e+k} + \frac{g}{c+e+k} Y^f - \frac{h}{c+e+k} Y^{ft} + \frac{d}{c+e+k} Y + \frac{c}{c+e+k} \ln w + \frac{e}{c+e+k} \ln p^d + \frac{k}{c+e+k} \ln p^f - \frac{b}{c+e+k} K_1 + \frac{u_d - u_s}{c+e+k} \qquad (8)$$

$$Q^x = \frac{ak+(c+e)f}{c+e+k} + \frac{bk}{c+e+k} K - \frac{ck}{c+e+k} \ln w - \frac{ek}{c+e+k} \ln p^d - \frac{dk}{c+e+k} Y + \frac{g(c+e)}{c+e+k} Y^f - \frac{h(c+e)}{c+e+k} Y^{ft} + \frac{k(c+e)}{c+e+k} \ln p^f + \frac{(c+e)}{c+e+k} u_d + \frac{k}{c+e+k} u_s \qquad (9)$$

Equation (8) is homogeneous of degree one in (w, p^d, p^f) and equation (9) is homogeneous of degree zero in the same set of variables.

3.3 Dynamic Adjustment of Supply and Demand

If there is lagged adjustment to relative prices in the supply and demand equations of Section 3.1, one may write

$$\ln S = a + b \ln K + \sum_{i=0}^{\infty} c_i \ln(p_{-i}/w_{-i}) + u_s \qquad (10)$$

$$\ln D = d + e \ln Y^f + \sum_{i=0}^{\infty} f_i \ln(p_{-i}/p^f_{-i}) + u_d \qquad (11)$$

The reduced-form price equation is then

$$\ln p = \frac{d-a}{c_o+f_o} + \frac{e}{c_o+f_o} \ln Y^f - \frac{b}{c_o+f_o} \ln K + \frac{co}{c_o+f_o} \ln w$$

$$+ \frac{f_o}{c_o+f_o} \ln p^f + \frac{u_d-u_s}{c_o+f_o} - \sum_{i=1}^{\infty} \left[\frac{c_i}{c_o+f_o} \ln(p_{-i}/w_{-i})\right]$$

$$- \sum_{i=1}^{\infty} \left[\frac{f_i}{c_o+f_o} \ln(p_{-i}/p^f_{-i})\right] \qquad (12)$$

This equation is homogeneous of degree one in current prices; therefore, lagged demand and supply response does not necessarily imply lagged price response. In order to have an equation that is not homogeneous of degree one in current prices, it is necessary to introduce an asymmetrical response to p and w in the supply equation and/or an asymmetrical response to p and p^f in the demand equation. For example:

$$\ln S = a + b \ln K + c_o \ln p + (c-c_o) \ln p_{-1}$$

$$- c_1 \ln w - (c-c_1) \ln w_{-1} + u_s \qquad (13)$$

$$\ln D = d + e \ln Y^f - f_o \ln p - (f-f_o) \ln p_{-1}$$

$$+ f_1 \ln p^f + (f-f_1) \ln p^f_{-1} + u_d \qquad (14)$$

Then

$$\ln p = \frac{d-a}{c_o+f_o} + \frac{e}{c_o+f_o} \ln Y^f - \frac{b}{c_o+f_o} \ln K + \frac{c_1}{c_o+f_o} \ln(w/w_{-1})$$

$$+ \frac{f_1}{c_o+f_o} \ln(p^f/p^f_{-1}) + \frac{c}{c_o+f_o} \ln(w_{-1}/p_{-1})$$

$$+ \frac{f}{c_o+f_o} \ln(p^f_{-1}/p_{-1}) + \ln p_{-1} + \frac{u_d-u_s}{c_o+f_o} \qquad (15)$$

If the response of supply and demand is more rapid with respect to w and p^f than to p (i.e., if $c_1 + f_1 > c_o + f_o$), prices can overshoot their equilibrium level. On the other hand, if supply and demand respond more rapidly to p, p will gradually adjust to its equilibrium level.

3.4 The Inclusion of Inventories

The inclusion of inventories will dampen the price response to certain types of shocks. The following set of linear equations, where prices are in logarithmic form, may serve as an example:

$$S = a + bK + c \ln (p/w) + u_s \tag{16}$$

$$D = d + eY^f - f \ln (p/p^f) + u_d \tag{17}$$

$$II = \theta_1 (K^d - KI_{-1}) - \theta_2 (D - D_{-1}) \tag{18}$$

$$K^d = kD_{-1} \tag{19}$$

$$S = D + II \tag{20}$$

where II is inventory investment and KI is the stock of inventories. Equation (18) describes inventory investment as partial adjustment to the desired stock of inventories (K^d, specified in equation (19)) plus a buffering of demand shocks by a fraction θ .

$$\begin{aligned} \ln p = \frac{1}{c + f(1-\theta_2)} & (c \ln w + f(1 - \theta_2) \ln p^f - (\theta_1 k + \theta_2) \\ & (f) \ln(p_{-1} - p^f_{-1}) - bK - u_s + (1 + \theta_1 k)d - a \\ & + (1 - \theta_2)eY^f + (1 - \theta_2)u_d + (\theta_1 k + \theta_2)eY^f_{-1} \\ & + (\theta_1 k + \theta_2)\, u_{d_{-1}} - \theta_1 KI_{-1}) \end{aligned} \tag{21}$$

The larger the demand buffer parameter θ_2, the less effect shocks in p^f, u_d or Y^f have on p. The effect of such shocks on output supplied will be less, and the effect on output demanded will be greater, than if there were no inventories. Equation (21) is, however, homogeneous of degree one in current prices and costs, and less weight is placed on p^f in the short run than in long-run equilibrium.

If the role of inventory investment were, on the other hand, to buffer supply shocks, one might specify:

$$II = \theta_1(K^d - KI_{-1}) - \theta_2 (S - S_{-1}) \quad (18')$$

$$K^d = kS_{-1}, \text{ so that} \quad (19')$$

$$\ln p = \frac{1}{c(1-\theta_2) + f} (c(1- \theta_2) \ln w + f \ln p^f + \ldots \quad (21')$$

Demand shocks (via p^f, u_d, or Y^f) will now have a greater impact on p in the short run so that output supplied will be greater and output demanded will be less than if there were no buffer to supply shocks. Of course there will be a smaller impact on p from supply shocks (via K, u_s, or w) so that the effect on output supplied will be more and the effect on output demanded less than if there were no supply buffer role.

3.5 Goldstein-Khan Supply Price Adjustment

Goldstein and Khan (1978) have proposed a price adjustment equation where the change in the price at which output is supplied is proportional to the discrepancy between output actually produced and desired ("normal") supply (S*), where desired supply depends on the capital stock (or capacity) and the ratio of the price to input costs (or to the over-all domestic price level):

$$\ln S^* = a + b \ln K + c(\ln p - \ln w) \tag{22}$$

$$\ln p - \ln p_{-1} = \lambda[\ln S - \ln S^*] \tag{23}$$

$$\begin{aligned} \ln p - \ln p_{-1} = {} & \lambda \ln S - \lambda a - \lambda b \ln K \\ & - \lambda c \ln p + \lambda c \ln w \end{aligned} \tag{24}$$

$$\begin{aligned} \ln p = {} & \frac{1}{1+\lambda c} \ln p_{-1} + \frac{\lambda c}{1+\lambda c} \ln w \\ & + \frac{\lambda}{1+\lambda c} \ln S - \frac{\lambda a}{1+\lambda c} - \frac{\lambda b}{1+\lambda c} \ln K \end{aligned} \tag{25}$$

$$\ln S = \frac{1+\lambda c}{\lambda} \ln p - \frac{1}{\lambda} \ln p_{-1} - c \ln w + b \ln K + a \tag{25'}$$

Implicit in Goldstein and Khan are imperfect competition in the short run and a downward sloping demand curve. In contrast to the dynamic adjustment of supply considered in subsection 3.3, the actual supply curve is not homogeneous of degree zero in current prices and costs. When taken together with a demand function depending on p/p^f, equation (25′) implies a larger supply response to changes in p^f in the short run than in the long run.

3.6 Oligopolistic and Other Pricing Rules

In the above subsections, supply behaviour has been considered that is either perfectly competitive in nature, or has long-run properties which are the same as a perfectly competitive model. In this subsection we deal with price-setting behaviour which does not necessarily have these properties.

Any number of oligopolistic pricing rules could be considered, but this section will be restricted to two major rules: a price-follower and an estimator of the equilibrium price.

A price-follower is defined here as one who follows a foreign price leader with a lag:

$$\ln p = \ln p_{-1} + \lambda(\ln p^f - \ln p_{-1}) \qquad (26)$$

The law of one price holds only in the long run; in the short run, price differentials enable one to estimate a demand curve since there is assumed to be a finite demand elasticity in the short run.

A firm attempting to estimate the equilibrium price will take into account information known at the beginning of the period (lagged prices and quantities) and that information it learns within the period (presumably incomplete). Its price equation will resemble a reduced form for the price from a supply/demand system, but will also include current output and extra lagged variables. Such an equation might look like the following:

$$\begin{aligned}\ln p = {} & a + b \ln p^f + c \ln w + d \ln S + e \ln K \\ & + f \ln p_{-1} + g \ln p^f{}_{-1} + h \ln w_{-1} \qquad (27)\end{aligned}$$

4 EMPIRICAL RESULTS ON PRICE AND SUPPLY IN THE SHORT RUN

This section reports some estimates of short-run supply and/or price equations estimated on quarterly data for 1971-80. The supply variable is the output of export-based resource industries. (Equations for the supply of exports were quite unsuccessful, perhaps because of the more volatile nature of the export series. See Appendix II.) Equations usually contain a dummy variable (d) which takes the value 1.0 in the last two quarters of 1975 and is zero elsewhere; this variable represents the effect of strikes. The capacity variable used (K) is that implicit in the Bank of Canada's capacity utilization series. Wages are represented by private business normal unit labour cost (ulc).[9]

The equations reported are various structural equations for supply, normalized on output or price, or reduced-form equations for price; they should be interpreted in the light of the models presented in Section 3.

4.1 Partial Adjustment Supply Equation

A partial adjustment supply equation was estimated in a more general form than equation (10) in that lags were included on all the explanatory variables and the dependent variable. The results of such a 2SLS estimation were:

$$\begin{aligned} \ln S = {} & \underset{(2.25)}{1.092} + \underset{(5.48)}{.868} \ln S_{-1} - \underset{(1.75)}{4.49} \ln K + \underset{(1.59)}{3.97} \ln K_{-1} \\ & - \underset{(1.88)}{.011} (\ln p - \ln ulc) - \underset{(.80)}{.104} (\ln p_{-1} - \ln ulc_{-1}) \\ & - \underset{(2.17)}{.051}\, d + \underset{(2.13)}{.055}\, d_{-1} + \underset{(1.32)}{.0028}\, TIME \end{aligned}$$

$\overline{R}^2 = .907$ D.W. = 1.77   S.E.E. = .0244

t-statistics are in brackets

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[9] The data are described in Appendix I.

This equation has the wrong sign on the capacity and relative price terms and so cannot be taken to represent supply adequately.

4.2 Goldstein-Khan Price Adjustment

The following were the estimated 2SLS equations for the Goldstein-Khan supply theory normalized on price and quantity respectively[10]:

$$\begin{aligned} \ln p = & \underset{(3.62)}{-1.434} + \underset{(10.32)}{.835} \ln p_{-1} + \underset{(1.17)}{.185} \ln ulc \\ & + \underset{(4.77)}{.504} \ln S - \underset{(1.07)}{.338} \ln K + \underset{(2.47)}{.049}\, d \end{aligned}$$

$\bar{R}^2 = .997 \quad$ D.W. = 1.68 $\quad$ S.E.E. = .0179

$$\begin{aligned} \ln S = & \underset{(4.27)}{2.461} + \underset{(4.93)}{1.326} \ln p - \underset{(3.05)}{.940} \ln p_{-1} \\ & - \underset{(2.50)}{.532} \ln ulc + \underset{(2.43)}{1.038} \ln K \\ & - \underset{(5.20)}{.111}\, d \end{aligned}$$

$\bar{R}^2 = .877 \quad$ D.W. = 1.52 $\quad$ S.E.E. = .0281

When the price equation was re-estimated constraining the coefficients on lagged price and normal unit labour costs to sum to 1 as required theoretically, the results were:

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[10] The equations are, of course, both to describe supply behaviour. With 2SLS, the coefficients are affected by the choice of the dependent variable.

$$\ln p = \underset{(3.66)}{-1.492} + \underset{(10.58)}{.854} \ln p_{-1} + \underset{(1.81)}{.146} \ln ulc$$

$$+ \underset{(5.22)}{.493} \ln S \underset{(1.12)}{-.253} \ln K + \underset{(2.50)}{.047} d$$

$$\overline{R}^2 = .997 \quad D.W. = 1.70 \quad S.E.E. = .0179$$

Whether one looks at the supply equation[11] or the price equation there is an indication of a significant (or almost significant) supply response to movements in price or normal unit labour costs. Each of the three above equations tells a generally believable story.

4.3 Price-Setting Equations

Does the law of one price hold in the data? Not contemporaneously:

$$\ln p = \underset{(1.62)}{.892} + \underset{(6.54)}{.804} \ln p_{-1} + \underset{(6.63)}{.616} \ln p^f$$

$$- \underset{(2.82)}{.426} \ln p^f_{-1} + \underset{(.03)}{.0004}\, d + \underset{(1.50)}{.34}\, u_{t-1}$$

$$\overline{R}^2 = .998 \quad D.W. = 1.88 \quad S.E.E. = .0135$$

The above equation indicates that there is only slow adjustment to the foreign price expressed in domestic currency (p^f). However, in the long run, the adjustment is almost complete (97 per cent) and the equation could be considered to be a price-setting equation. The following equation was run to determine whether there are any domestic determinants of prices:

---

[11] Lagged normal unit labour costs were insignificant when added to the equation.

$$\ln p = \underset{(1.88)}{.880} + \underset{(8.04)}{.806} \ln p_{-1} + \underset{(6.92)}{.569} \ln p^{f} - \underset{(3.48)}{.396} \ln p^{f}_{-1}$$
$$- \underset{(.34)}{.0034}d + \underset{(2.70)}{.728} \ln ulc - \underset{(2.91)}{.700} \ln ulc_{-1}$$

$\overline{R}^2 = .999$ D.W. = 1.74 S.E.E. = .0126

Domestic normal unit labour costs are an important determinant of prices in the short run, but the long-run elasticity of price with respect to normal unit labour cost is .15 (with respect to foreign prices it is .89). Such an equation would be in keeping with a significant output response to a rise in foreign prices or a decline in domestic normal unit labour costs when taken together with a downward sloping demand curve (depending on p/p^f). Figure 5 graphs the response of p/p^f to a -1 per cent shock in p^f and to a 1 per cent shock in ulc. It can be seen that the lagged adjustment implies larger increases in the relative price term in the short run than in the long run.

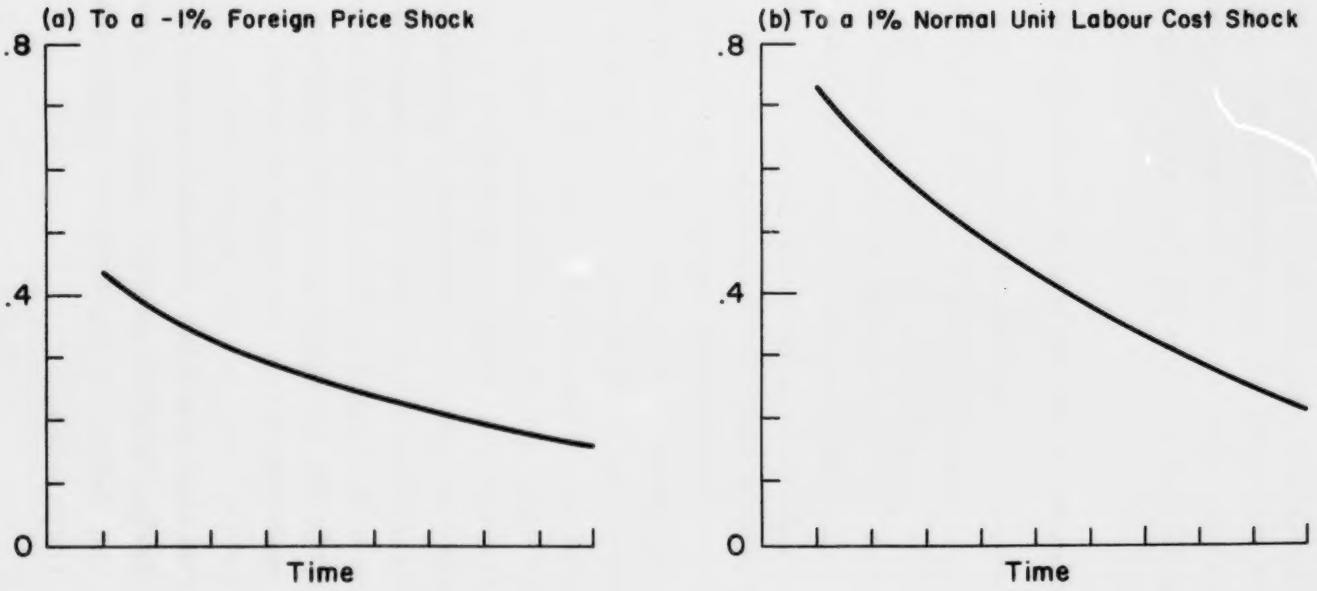
The above equation was re-estimated using 2SLS with the addition of current output and capacity to determine whether they had a significant impact on the price. No significant response was found:

$$\ln p = \underset{(1.11)}{.618} + \underset{(7.58)}{.853} \ln p_{-1} + \underset{(6.62)}{.575} \ln p^{f} - \underset{(3.43)}{.426} \ln p^{f}_{-1}$$
$$+ \underset{(1.68)}{.616} \ln ulc - \underset{(2.18)}{.626} \ln ulc_{-1} - \underset{(.35)}{.0036}\, d$$
$$+ \underset{(1.15)}{.0059} \ln S + \underset{(.11)}{.026} \ln K$$

$\overline{R}^2 = .999$ D.W. = 1.77 S.E.E. = .0131

Figure 5

THE RESPONSE OF THE RATIO OF DOMESTIC TO FOREIGN PRICES


(a) To a -1% Foreign Price Shock

(b) To a 1% Normal Unit Labour Cost Shock

Two models of supply have been shown (when taken together with a downward sloping demand curve) to imply significant exportable output responses to both increases in foreign prices and declines in domestic normal unit labour cost. This is in contrast with much of the earlier work done at the Bank of Canada in the context of the RDXF model.

5 INVESTMENT IN EXPORT-BASED RESOURCE INDUSTRIES

The above section has shown that there is some evidence of a "short-run supply response" from an increase in the prices of resources relative to unit costs. One would then like to know whether there is a longer run response through increased capacity. In particular: (i) Has the most recent period been characterized by more or less investment than one would have expected on the basis of the experience of the 1960s and early 1970s? (ii) Is there any evidence that the price of resources relative to labour costs has a direct impact on the investment decision? and (iii) What explains the low levels of investment in the 1976-79 period? (See Figure 6.)

Annual data are available for business fixed investment. After provision for lags it is possible to estimate a model for the 1963-80 period. The model chosen is the stock adjustment model of RDXF where the desired capital stock depends on a distributed lag on output (accelerator term) and the rental price of capital goods relative to the price of labour. The following notation is used:

I	is real business fixed investment,
K	is the end-of-period capital stock, represented by the index of capacity in export-based resource industries,

PC	is the rental price of capital (the price of capital goods times the sum of the depreciation rate and the real supply price of capital, adjusted for corporate income taxes),
PL	is the price of labour,
PRDP	is the price of output,
RDP	is real output, and
ULC	is normal unit labour cost.

The model may be represented as:

$$I/K_{-1} = a + b \ln(RDP) + c \ln(RDP_{-1}) + d \ln(RDP_{-2}) + e \ln(PC/PL)_{-1} + f \ln(K_{-1})$$

The term PRDP/ULC can be included to test whether the price of output in terms of labour cost has an independent effect on the desired capital stock.

Table 1 contains the estimation results. Equation (1) is the basic equation. All the explanatory variables are significant and of the correct sign. Equation (2) indicates that the lagged rental price to labour cost variable does not significantly add to the explanatory power of the regression. Equations (3) and (4) indicate that the current and lagged relative prices of output to normal unit labour cost, respectively, do not reduce the standard error of the regression. The final specification of the investment equation indicates that there is little further lagged response of investment to be expected from the increase in the relative price of export-based natural resource output, since that price increase had little effect on output.

Figure 6

RATIO: INVESTMENT TO LAGGED CAPITAL STOCK

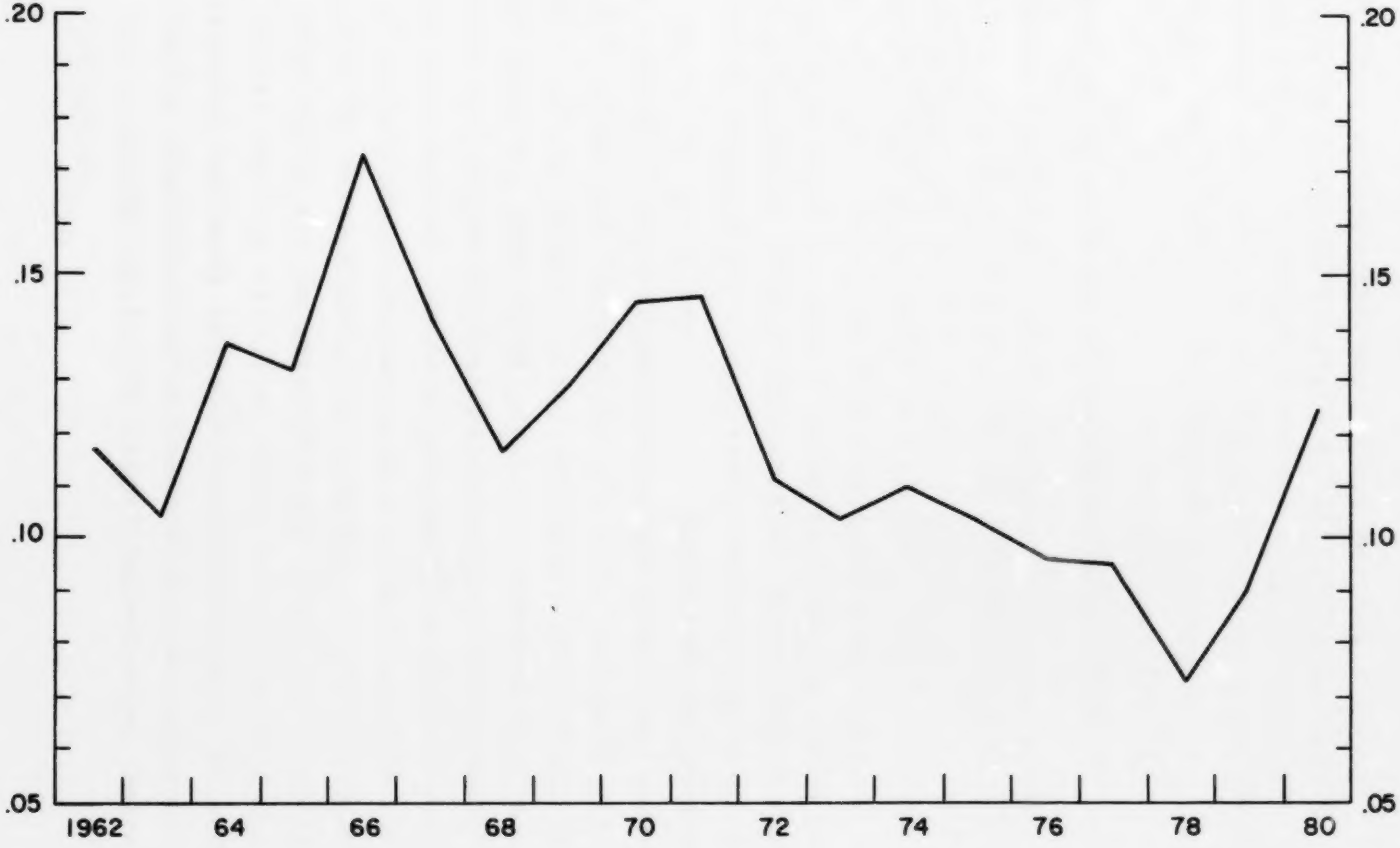


TABLE 1

INVESTMENT IN EXPORT-BASED RESOURCE INDUSTRIES 1963 to 1980
(Dependent variable I/K_{-1})

Equation	Constant	k_{-1}*	rdp	rdp_{-1}	rdp_{-2}	pc-pl	$(pc\text{-}pl)_{-1}$	prdp-ulc	$(prdp\text{-}ulc)_{-1}$	$\bar{R}^2$	D.W.	S.E.E.
(1)	1.245 (7.10)	-.675 (6.57)	.277 (3.29)	.390 (4.38)	.213 (2.66)	-.244 (4.91)				.795	2.25	.0111
(2)	1.272 (4.03)	-.683 (5.23)	.270 (2.56)	.395 (3.86)	.223 (1.71)	-.240 (3.94)	-.009 (0.10)			.777	2.25	.0116
(3)	1.275	-.677 (6.45)	.287 (3.29)	.390 (4.29)	.222 (2.68)	-.226 (3.95)		-.033 (0.70)		.786	2.38	.0114
(4)	1.337	-.687 (6.35)	.277 (3.19)	.397 (4.28)	.231 (2.58)	-.239 (4.60)			-.029 (0.53)	.782	2.37	.0115
(5) [1963-75]	.999	-.667 (5.85)	.314 (3.48)	.250 (1.92)	.335 (2.28)	-.209 (4.31)				.759	2.84	.0104

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* Lower case denotes logarithms

In order to examine the stability of the equation for the recent time period it was first re-estimated for the 1963-75 period. The forecast residuals from that regression are displayed in Table 2, where it is seen that there are large negative residuals (i.e., overprediction by the equation) in 1976, 1978 and 1979. However, an F test does not reject the null hypothesis of no change in the structure after 1975. The equation was then updated a year at a time checking for the significance of one-year-ahead forecast residuals. The results are found in Table 3 where it is seen that although all the residuals are negative, none is statistically significant. However, the residuals are of such a size as to be economically very important.

The part of the decline in the I/K_{-1} ratio in 1976-79 that is explained by the equation comes primarily from the output terms, although there was some increase in the relative cost of capital in 1978 and 1979.

6 CONCLUSIONS

Two of the approaches used were found to imply a significant short-run output supply response to a rise in foreign prices or a decline in domestic normal unit costs.[12] The response to foreign price shocks for a given capital stock, however, is likely to be larger in the first quarter than over time.[13]

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[12] This assumes that the model is completed by a downward-sloping foreign demand curve such as those in the Bank of Canada's RDXF model.

[13] In the Goldstein-Khan output equation, the long-run price elasticity of supply is less than in the short run, and in the price-setting equations, the domestic price depends more on foreign prices as the period of time lengthens.

TABLE 2

FORECAST RESIDUALS FOR EQUATION (5)

Year	Residual
1976	-.0253
1977	.0040
1978	-.0233
1979	-.0263
1980	-.0037

$F_{5,\,7} = 1.36$ (critical $F_{5,\,7,\,.05} = 3.97$)

TABLE 3

ONE-YEAR-AHEAD FORECASTS (out of sample)

Year	Residual	t-statistic
1976	-.0253	-1.15
1977	.0000	0
1978	-.0219	-1.92
1979	-.0150	-1.12

The capital stock increases as investment responds to demand through an accelerator term. This effect is found to be significant in equations estimated to the end of 1975 or to the end of 1980. Although there is no statistically significant change in the coefficients of the investment equation from 1975 to 1980, investment fell short of the predicted level on the basis of the 1975 equation by some 2.5 per cent of the capital stock in 1976, 1978 and 1979. The last two residuals are surprising in that the effects on profitability of the 20 per cent depreciation of the Canadian dollar plus an increase in the U.S. dollar price of raw materials might have led one to believe that investment would have been above what the investment equation, which does not capture profitability directly, predicted. However, there may have been a lot of uncertainty over the permanence of the depreciation and/or the relative price of natural resources on world markets.[14] The range of expectations about the future exchange rate may well be narrowing over time. By 1980, the 1975 investment equation is back on track and there are indications from Statistics Canada's mid-year investment survey that real investment in export-based resource industries may increase by over 20 per cent in 1981 (a very large increase even though smaller than the 42 per cent recorded in 1980), which would mean that the equation would be underpredicting.

If one takes the estimated short-run supply and investment equations together, it appears that the short-run response of output is not sufficiently large to engender an expectation of a large permanent increase in output demand (through the accelerator). Thus a relatively weak short-run supply response leads to a relatively weak long-run supply response.[15] This is the way the equations account for the 1978-79 period.

In terms of explaining the downward shift in the export-based resource industries' share in total output, this paper has only gone part of the way. Low short-run supply elasticities and below-normal fixed investment may be interesting findings, but it is left for further research to determine what factors underlie these econometric explanations.

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[14] Another possible reason for the low investment levels may be that the marginal cost curve for the establishment of new mines might be rising sharply because of the quality and location of alternative bodies of ore and/or the stricter environmental regulation of new mines.

[15] To the extent that rising energy prices made some of the existing capital stock obsolete, the small increase in the measured capital stock overpredicts the actual increase in productive capacity.

APPENDIX I: THE DATA

1. **Quarterly** (RDXF data base equivalents in brackets)

d is a dummy variable to represent strikes. Takes the value 1 in 1975Q3 and 1975Q4; 0 elsewhere.

K is the index of capacity in export-based resource industries. Real domestic product in export-based resource industries divided by Bank of Canada's capacity utilization rate for export-based resource industries.

p is the price of output in export-based resource industries. Weighted average of industrial selling price index in wood, paper and allied and primary metals industries where the weight on primary metals includes the weight for mining excluding oil and natural gas.

p^f is the foreign price of wood, paper and allied products and metals. Weighted average (Canadian 1971 RDP weights) of U.S. wholesale price indexes for: pulp and paper (PWPP2), lumber (PWLUM2), ferrous metals and non-ferrous metals.

px is the export price for export-based resource industries. Weighted average of export prices for: lumber (PXLUM), other forest products (PXFPO) and metals and minerals excluding oil and natural gas (PXMMO).

S is output of export-based resource industries. Weighted real domestic product in wood products (.134), paper and allied products (.255), primary metals (.273) and mining excluding oil and natural gas (.338). The weights in brackets are 1971 weights.

ulc is normal unit labour costs in private business (ULC).

X is exports of export-based resource industries in 1971 dollars. Sum of exports of lumber (XLUM), other forest products (XFPO) and metals and minerals excluding oil and natural gas (XMMO).

2. Annual

I	is investment in export-based resource industries (1971 dollars) (CANSIM data base);
K	is end-of-year capital stock in export-based resource industries (CANSIM data base);
PC/PL	is the ratio of rental price of capital (.5RCME + .5RCNR) to hourly wage in mining and manufacturing (approximated by WNICIR/HAWMM);
PRDP	is the average of quarterly p; and
ULC	is the average of quarterly ulc.

3. Instruments for 2SLS Regressions

The following variables were used as instruments in the price and supply equations: the exogenous variables in the equation, real U.S. GNE (UGNE2); weighted industrial production in other major OECD countries (Japan, Germany, Italy, France and the United Kingdom, (UF)); real Canada GNE (UGNE); and p^f.

APPENDIX II: RESULTS FOR EXPORTS

The following equations parallel the output equations given in the text.

Goldstein-Khan (Section 4.2)

$$\ln px = \underset{(1.56)}{-.472} + \underset{(11.81)}{1.041} \ln px_{-1}$$

$$\underset{(.89)}{-.189} \ln ulc + \underset{(1.14)}{.072} \ln S$$

$$\underset{(1.19)}{+.499} \ln K - \underset{(1.74)}{.036}\, d$$

$\overline{R}^2 = .995$ D.W. = 1.63 S.E.E. = .0271

$$\ln X = \underset{(25.64)}{8.326} + \underset{(.18)}{.009} \ln px + \underset{(1.86)}{.367} \ln px_{-1}$$

$$\underset{(1.49)}{-.694} \ln ulc + \underset{(1.59)}{1.441} \ln K$$

$$\underset{(5.94)}{-.264}\, d$$

$\overline{R}^2 = .637$ D.W. = 1.32 S.E.E. = .0599

Price terms constrained to add to 1.0 in Goldstein-Khan

$$\ln px = \underset{(1.26)}{-.357} + \underset{(18.27)}{.964} \ln px_{-1} + \underset{(.41)}{.036} \ln ulc$$

$$\underset{(1.32)}{+.082} \ln S + \underset{(.49)}{.071} \ln K - \underset{(1.55)}{.032}\, d$$

$\overline{R}^2 = .995$ D.W. = 1.46 S.E.E. = .0270

Price-Setting (Section 4.3)

$$\ln px = \underset{(76.31)}{-4.258} + \underset{(2.57)}{.663} \ln px_{-1}$$

$$\underset{(.44)}{-.110} \ln p^{f} + \underset{(.75)}{.269} \ln p^{f}_{-1}$$

$$\underset{(1.94)}{+1.41} \ln ulc - \underset{(1.83)}{1.21} \ln ulc_{-1}$$

$$+ \underset{(2.77)}{.083}\, d$$

$\overline{R}^2 = .991$ D.W. = 1.61 S.E.E. = .0365

$$\ln px = \underset{(1.56)}{.675} + \underset{(5.59)}{.686} \ln px_{-1}$$

$$+ \underset{(5.06)}{.634} \ln p^{f} - \underset{(2.06)}{.348} \ln p^{f}_{-1}$$

$$+ \underset{(2.23)}{1.026} \ln ulc - \underset{(2.58)}{.921} \ln ulc_{-1}$$

$$\underset{(1.58)}{-.078} \ln X + \underset{(.07)}{.021} \ln K$$

$\overline{R}^2 = .998$ D.W. 1.68 S.E.E. = .017

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DISCUSSION

Javier Cardenas began the discussion with the observation that the supply function of natural resource-based output was of great relevance to Mexico as well as to Canada. However, he thought that an intertemporal approach with allowance for price expectations, discount rates, and for the costs of location and exploitation, would be more appropriate for this sector than the conventional supply functions estimated by Longworth. Cardenas was also concerned that in the price equation the lagged dependent variable might simply pick up residual autocorrelation rather than a dynamic reaction. Longworth replied that statistical checks in fact confirmed the hypothesis of a lagged dynamic adjustment.

John Helliwell was not surprised that the proportion of output in resource-based industries showed a secular downtrend, because of an essentially limited endowment. One would likewise expect the trend rise in the relative price of raw materials. Longworth made the point that his primary objective was to isolate the effects on output of the more rapid increases that took place in the 1970s. These increases might have been expected to have had a more positive effect on the sector's share of total output than is apparent in the data, the long-term decline notwithstanding.

5 WORKSHOP SUMMARY

WORKSHOP SUMMARY

A FINANCIAL MODEL FOR MEXICO: A RATIONING OF CREDIT APPROACH

Javier Cardenas and Angel Palomino

Bank of Mexico

THE COST AND REVENUE STRUCTURES OF COMMERCIAL BANKS IN MALAYSIA

T.F. Chung, N. Sulaiman and T.S. Ho

Bank Negara Malaysia

The following is a summary of and the resulting discussions on two papers presented at an informal workshop session; both papers reported on projects that are still in early stages of development.

Javier Cardenas and Angel Palomino outlined the general characteristics and structural features of a financial model presently being prepared at the Bank of Mexico. Eventually the model will be used to determine the effects of changes in the instruments of monetary policy on the macro economy. The central assumption incorporated in the model is that monetary policy operates via the domestic supply of credit. The rationing of credit is viewed as an important part of the transmission mechanism of monetary policy to the non-financial economy. This financial-real linkage is specified in terms of the effect on aggregate demand and aggregate supply of changes in the "credit deficit", that is, of changes in the excess demand for credit (i.e., notional domestic demand less supply, including net foreign capital imports). By manipulating the instruments of Mexican monetary policy, such as the interest rate paid on savings deposits and/or the reserve requirements, the domestic supply of credit may be altered and, thereby, affect the non-financial side of the economy.

The structure of the theoretical model incorporates the effect of public sector operations. The sector's budget deficit is expressed both in terms of national income flows and cash requirements. For the external sector, components of both the current and capital accounts are modelled. Also incorporated are the credit market, the demand for financial instruments (both domestic and foreign) by residents, and aggregate demand and supply for real goods and services. The structural equations are reduced by algebraic substitution to four "reduced-form" equations which explain aggregate demand, aggregate supply, the "credit deficit", and international reserves. Finally, preliminary estimates of the reduced-form model are made using a variety of estimation techniques.

The authors point out that from an econometric viewpoint, the central assumption underlying the model creates a problem: namely, despite the notional inequality between credit demand and supply, there is only one quantity observed ex post. The gap between ex ante demand and supply must be inferred indirectly. A variety of measures to proxy the "credit deficit" concept are currently being studied. The authors also acknowledge the limitations of the aggregate supply equation. The significant development of the oil sector in the Mexican economy has led to wide differences between the characteristics of the oil and non-oil sectors; consequently, a single supply equation is probably an over-simplification.

Charles Pigott thought that the work reported from the Bank of Mexico was innovative and useful for analyzing a financial market that is relatively undeveloped and tightly controlled. The paper spells out very clearly the close link between money creation and the fiscal deficit that exists in Mexico. However, knowledge of the structural relationships, not just reduced forms, is necessary to trace out the likely effects of changes in regulations such as credit controls, interest rate ceilings, and the like. Pigott suggested that the time perspective of the model could be lengthened so that the longer run outcomes of exogenous changes might be studied more explicitly.

The paper from the Bank Negara Malaysia discusses a study undertaken to examine the cost and revenue patterns of commercial banks in Malaysia for the 1965-80 period. This particular report represents only one part of a much broader study undertaken to assess the transmission of monetary policy to both the financial and non-financial sectors.

The authors report that the results of the time series analysis were "rather unsatisfactory". They speculate that the cost and revenue specifications may be the source of the problem since there were methodological problems associated with establishing the appropriate cost and revenue units of the commercial banks.

The cross-sectional analysis of the revenue and cost structures proved somewhat more encouraging. Based on a Cobb-Douglas-derived cost function, a model previously used at the Federal Reserve Bank of Boston, the main observation was that the interest rate and wage variables do not contribute significantly in most of the cost and revenue equations estimated. Moreover, the results also corroborate the authors' earlier observation on the distinct differences between domestic and foreign banks with respect to their cost and revenue structures.

The authors' work broke new ground as an econometric investigation of a less-developed financial system, but David Rose found some instances in which the rigour of the analysis might be increased. He and some other commentators recommended that a more effective research strategy might be to pursue separately the questions of structural efficiency and monetary control. The former topic devolves essentially upon microeconomic problems and has implications for financial legislation and regulation. Monetary control, on the other hand, is concerned primarily with macroeconomic issues relating to central bank policy. It is perhaps too ambitious to investigate both topics within a unified framework. It was felt that the cross-section data used by the authors were a valuable source for investigating the characteristics of the Malaysian financial system.

6 A SUMMING UP

A SUMMING UP

John F. Helliwell

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A SUMMING UP

The main Conference sessions started with two papers using multi-country models to show the national and international effects of rises in world oil prices. Peter Hooper used the Federal Reserve Board's five-country model (MCM) to examine the effects of OPEC II (the 110 per cent increase in real world oil prices between the end of 1978 and the end of 1980) over the 1978-82 period under a number of different assumptions about OPEC investment and spending strategies. Anne McGuirk used the IMF's Multilateral Exchange Rate Model (MERM) to analyze the 1985 trade and exchange rate changes implied by the impact on the seven largest industrial countries of OPEC I and OPEC II considered together, amounting to a seven-fold increase in world oil prices.

To help understand and compare the two sets of results, it may be useful to spell out some of the differences and similarities in the model structures as follows.

GNP in each of the five countries and the OPEC trade balance are endogenous in the MCM, while GNP is held fixed (by implicit changes in monetary and fiscal policy) in each MERM country, and OPEC is assumed to spend all the extra income generated by the oil price increases. These differences between the models are minimized in Hooper and Tryon's Case 4, where OPEC spending is increased to absorb most of the additional oil revenues.

Oil demand in Peter Hooper and Ralph Tryon's paper is assumed to have a unit income elasticity of demand and a price elasticity (with respect to the national crude oil price) ranging from -.19 to -.41 in the five countries modelled. Oil demand in all other countries is assumed to be exogenous so their balances of trade worsen by these quantities times the increase in oil prices. In Anne McGuirk's paper, the 1985 total energy demand projections for the high oil price case are based on IEA projections, while for the low price case they are based on forecasts of 1985 GDP and OECD estimates of the income elasticity of energy demand.

For comparison, the MCM elasticities of oil demand with respect to the oil price and the implied MERM elasticities of total primary energy demand with respect to the price of crude oil, for the five countries in common, are:

	MCM	MERM
Canada	-.192	-.005
United States	-.248	-.030
Japan	-.198	-.037
Germany	-.313	-.034
United Kingdom	-.411	-.013

Since the MERM assumptions apply to total energy and the MCM results to crude oil, they cannot be compared directly without some analysis of the movements in other energy prices and the changes in energy shares following changes in the price of crude oil. To give a rough idea of the necessary conversions, the results in Table 4.2 of the Helliwell, Boothe, and McRae paper (referred to in my opening talk) show that using world crude oil prices (and comparable natural gas prices) in Canada in 1980 would have meant doubling the crude oil price, increasing the weighted average price of energy to final users by 50 per cent, reducing the total quantity of energy used by 17 per cent and cutting the quantity of crude oil used by about 25 per cent. These results would vary for different countries and with different models of inter-fuel substitution, but they nevertheless suggest that the MERM assumptions about demand response are substantially below those of the MCM and most other estimated models of energy demand in the OECD countries.

Energy supply in the five MCM countries is assumed to be exogenous. In the MERM experiments, Anne McGuirk's Table 5 results assume no energy supply response, while her Table 7 results assume an energy supply response (in Canada, the United States, and the United Kingdom) totalling 338 MTOE (millions of tons of oil equivalent) in 1985, or 16 per cent of the estimated 1985 low price production of total primary energy in the seven largest OECD economies.

If the price change assumptions and the energy supply and demand assumptions in the two models are put together, it is possible to determine the approximate size of the "oil shock", i.e., the increase in oil import expenditures in each of the five countries covered by both models. Some results are summarized in the following table: the MCM results relate to 1982, and the MERM results to 1985; a negative sign indicates an increase in net imports.

	MCM (billions of 1982 U.S. dollars)	MERM with exogenous supply (billions of 1985 U.S. dollars)	MERM with supply response (billions of 1985 U.S. dollars)
Canada	- 2.4	+ 8.1	+10.1
United States	-27.4	-78.2	-64.7
Japan	-30.8	-92.6	-92.6
Germany	-19.8	-37.5	-37.5
United Kingdom	+ 3.8	+ 5.1	+ 6.7
Total	-76.6	-195.1	-178.0

Note: The MCM figures are the 1982 figures from column 1 of Tables 7 through 11 of the Hooper and Tryon paper, converted to billions of U.S. dollars at September 1981 exchange rates.

To a rough approximation, the MCM and MERM shocks are of the same size and sign for the United Kingdom, while the MERM shock is two or three times as large as the MCM shock for the United States and Germany, and twice as large for Japan. The MERM oil shock for Canada has a positive sign, while that for MCM is negative.

The real exchange rate changes in the MCM depend on OPEC's (and other countries') financial preferences as well as on trade preferences and absorption levels. In MERM, output levels are fixed and portfolio preferences are passive, in the sense that whatever national trade balances are determined by supply and demand equilibrium in the 20 goods markets are accepted without requiring any change in exchange rates. That this is an important difference between the models can be seen by comparing the MCM Cases 1 to 3 which show, for example, that the 1982 value of the DM would be 15 per cent higher if one third of OPEC surpluses were invested in DM-denominated assets than if none were invested in DM assets. This difference between the models is minimized if one concentrates on the MCM Case 4, where almost all of incremental OPEC revenues is spent on imports.

Both models spread OPEC's imports among exporting countries on the basis of exogenous shares, based on 1972 weights in the case of MERM and 1978 for MCM. This difference could be important for countries whose shares of the OPEC market have changed substantially.

When computing the trade responses to exchange rate and other relative price changes, the MCM system implicitly alters input-output coefficients and the industry mix of production, while the MERM holds input-output coefficients constant for each industry and explicitly alters each country's industrial mix.

If we bear in mind all these differences, it may be useful to compare the 1982 MCM Case 4 results with the MERM results with no energy supply response. A minus sign denotes a devaluation relative to the U.S. dollar.

	MCM: Nominal	MCM: Real	MERM: Real
Canada	- 2.1%	- 5.9%	+13.8%
Japan	- 8.2%	-11.0%	-15.8%
Germany	-13.3%	-13.5%	+ 3.3%
United Kingdom	+27.0%	+18.0%	+35.5%

If we remember that the MCM and MERM shocks are of roughly the same sign and size for the United Kingdom, while the MERM shocks are two or three times as big as the MCM shocks (but of the same sign) for Germany, Japan and the United States, the results from the two models are rather different, being even of different signs for Germany. The Canadian results are roughly as expected, given that that the oil price shock involves an initial Canadian balance of trade deterioriation in MCM and an improvement in MERM. Comparing exchange rate results from the two models is made especially difficult by the fact that allowance has to be made for inter-model and inter-country differences in the initial impact effects. It is noteworthy that both models imply a substantial petrocurrency role for sterling, and implicitly attribute a good part of the pound's post-1976 strength to oil price increases.

Finally, I should note that it would be easier to compare the properties of the two models, and to assess the implications of their different structures, if their operators were to get together and design an oil price experiment that gave approximately the same initial shock over the same horizon, and with the same distribution of OPEC purchases. Even then, to get to the root of the reasons for the remaining differences, it might be useful to impose fixed interest rates and perfect capital mobility to help isolate the effects of the portfolio balance terms.

One final suggestion may be too many, but it would generally make the results of both models more illuminating if the country-by-country responses to the oil price shocks could be shown both with and without the interactions with other countries. This would have a double payoff, as it would permit the checking of the national results, especially of the MCM, against results from current national models of the same countries, and it would permit builders and users of national models to see what they are missing when they analyze oil price shocks without considering the induced effects on their non-OPEC trading partners.

Charles Pigott presented a useful decomposition of the variance of the U.S. dollar exchange rate with six currencies into its real and purchasing-power parity components. In my view, the paper dealt with two important issues and left a third one unresolved.

The key evidence in Pigott's paper, and replicated in other studies, is that changes in purchasing-power parity have been responsible for only a small proportion of the total monthly variance of exchange rates from 1973 to 1980.

Pigott then tested for persistence of changes in real exchange rates, with and without allowance for differences in expected inflation rates as proxied by differences in nominal interest rates. He concluded that the persistence of real exchange rate changes was too pervasive to permit the static monetary overshoot hypothesis or other transient financial adjustments to be used to explain post-1973 departures from purchasing-power parity.

However, the implications of Pigott's analysis for monetary and exchange rate policy are not considered at length in his paper, but do deserve some attention. Does the persistent variability of real exchange rates reflect relative price changes that are a necessary part of the optimal evolution of the trade and investment balances, or are they autocorrelated and misleading errors on the part of participants in the foreign exchange market? If they are the former, then, for example, a policy of adjusting the exchange rate so as to maintain purchasing-power parity is likely to increase adjustment problems by exaggerating the size of the change in the domestic price level required to create the necessary change in the terms of trade.

If the persistence of real exchange rate changes is held to be a false signal of future comparative advantage, and hence to provide grounds for using monetary policy to offset it, then it is necessary either to assume that the PPP rate is the equilibrium rate or somehow to disentangle the variance of the real exchange rate into its necessary and its misleading components. This raises the issue concerning the relative amounts of information in the hands of policymakers and the private markets. If policymakers believe they have superior information they can either adjust policy accordingly or simply publish the information.

The effects of supply shocks were considered in the national models of both Korea and Australia. Both papers concentrated on the effects of alternative monetary policy reactions to the supply shock, and the two models had important common characteristics.

Although neither model ascribes an explicit role to imported energy or other materials in the determination of potential output, both are relatively unusual in that they have behavioural equations for the level of output, with inventory stocks playing a passive buffer role in absorbing or making up any difference between production and sales. Thus they are both, in an important sense, supply-determined models in that the current level of output is determined by the production decision rather than by the level of final demand. This feature should not be overstressed, of course, since it is a feature of any model with an explicit buffer stock role for inventories. If the production decision is itself affected by supply shocks, as with the appearance of the import price (relative to the wholesale price, with an elasticity of -.08) in the production equation in the Korean model, then the analysis starts to look rather different from that of demand-determined systems. In the Korean model, this channel of influence flows through the wage terms in the wholesale price equation, and thus augments the direct appearance there of the import price. The level of output has no other role in the current version of the model, however, as there is no feedback from the inventory stock to prices, imports, factor demands, or output. When the level of employment is made endogenous, it might be appropriate to respecify the output equation to relate it to an explicit factor-based measure of potential output, as well as to the difference between actual and desired inventory stocks, as is done, for example, in the Australian model used in John Taylor's paper, as well as in the New Zealand Core model and the Canadian MACE model.

In the Korean paper, Dae Sik Kim noted that a 10 per cent increase in import prices appeared to raise the wholesale price 5.3 per cent in the same year, with a small subsequent additional effect. The higher price levels cut real money balances and hence spending. Kim considers the possible use of contractionary monetary policy to constrain the inflation, and concludes that it would make the stagflation worse. A considerable amount of subsequent discussion dealt with this issue, and more generally with the effects of monetary policy in the model. It was seen (by comparing simulations 3 and 4) that the nature of the price and output effects of monetary policy in the model was quite orthodox, in that increasing the money supply increases both output and prices. What is unusual is the apparently attractive trade-off between the output gain and the inflation cost; a 20 per cent increase of M2 (simulation 3 versus simulation 4) giving, in the fifth year, GNP that is .33 per cent higher and a price level that is only .6 per cent higher. This may seem unlikely, but it should also be remembered that a fixed exchange rate is assumed and reserves are draining away at a great rate (imports up by 1.5 per cent), so the policy strategy would have to change soon. In any case, the small inflation-fighting effects of monetary policy (in part because the interest rate appears as one of the cost elements in the wholesale price equation) are the reason for the author's conclusion that tight money did not ease the stagflationary effect of import price increases.

The tone of the Australian paper was rather different. John Taylor argued, on the basis of simulations with RBII, the Reserve Bank of Australia's pathbreaking research model, that different monetary reaction functions did not do much to alter the effects of wage shocks, foreign price shocks, or a reduction in capacity output. He then went on to argue, on the basis of a possible negative effect of inflation on consumption spending, that for monetary policy to underwrite an inflationary supply shock could be counter-productive. There was considerable discussion about whether these conclusions followed from the structure of the model or from the particular simulation assumptions employed.

On the issue of the effect of inflation on savings, a number of hypotheses were considered, with no consensus that a higher expected inflation rate, for given real income and tax rates, should lead to lower spending. I will return to this issue later, as it is raised also by the Japanese paper presented by Hiroshi Yomo.

On the issue of monetary policy offsets, it was suggested that it would be more in the spirit of the reaction function approach of RBII to alter the monetary policy reaction function to offset the predictable output effects of supply shocks, if that was the assumed goal of the policy. If inflation-fighting was the goal, and high import prices the shock, then the interest rate would of course be preemptively raised rather than lowered. The monetary rules tested do provide some effect, but the lagged role of money in the model is such that any successful monetary policy strategy in response to short-term disturbances is likely to require interest rate adjustments at the time the shock appears.

Although both the Korean and Australian papers used interesting models to address interesting policy questions, they probably did no more to focus our attention on the difficulties of designing and interpreting policy experiments than to decide the issue of whether and when the monetary authorities ought to act to offset either the output or the price effects of stagflationary supply shocks.

There were two more single country assessments of the effects of energy prices, one using the Bank of Canada's new annual model SAM, and the other using the Bank of Japan model. The Bank of Canada paper, presented by David Rose, was concerned with the effects of domestic energy prices for given world energy prices, while the Japanese paper analyzed the effect of an equivalent change in domestic and world energy prices. Several issues were treated in both papers, while other matters were specific to one paper or the other. I shall deal with the general issues first.

Both papers emphasized the likely importance of treating energy as an explicit factor of production. This was central to David Rose's finding that, with output held constant, a rise in the price of energy would lead to a rise in employment, and to Hiroshi Yomo's Figure 2 showing the kinks in potential output growth caused by the OPEC I and OPEC II oil price shocks. Hiroshi Yomo argued that such an explicit treatment of energy would increase the ability of aggregate models to depict the stagflationary effects of energy price increases. These effects would, of course, lessen the apparent size of the post-price-shock output gap, and weaken the case for using expansionary policies to sustain absorption following an import price shock.

The second important issue is how one should use the measure of potential output based on an explicit treatment of energy and other factor inputs. The current version of the Japanese model assigns the capacity utilization rate a significant role in the determination of the quantities and prices of exports. If the factor-based measure of potential output were substituted for the denominator of the present capacity utilization rate, then the higher energy prices would reduce the export supply performance of the Japanese economy, thus providing an additional channel of influence. Actual output is demand-determined subject to this current and lagged feedback from capacity to exports.

By contrast, in the current version of the Bank of Canada model, the level of output is determined by the production function, the utilization rate is constrained to unity, and inventories are used to absorb any supply-demand discrepancy. As I suggested in my opening talk, I prefer the intermediate position adopted in the Australian RBII model, the New Zealand Core model, the Korean model, and the MACE model, using a behavioural equation for the production level, with factor-based potential output, current sales, and inventory stock discrepancies, and the ratio of output price to current operating cost as the key explanatory variables. It is perhaps worth noting that in the MACE model the standard error of the estimate of actual output is 1.74 per cent ($\overline{R}^2 = .9974$) if the production function (with average utilization rates imposed) is the only explanatory variable, but drops to .45 per cent ($\overline{R}^2 = .9998$) if these other variables are included. For comparison, the $\overline{R}^2$ of the directly estimated SAM production function is .998.

The change in inventories is then determined by the identity linking production and sales. This has the potentially attractive feature of making the utilization rate the result of an explicit production decision, and has the effect of splitting any unexpected change in sales between inventory changes, changes in the utilization rate, and changes in measured factor inputs.

Third, the Japanese model, and to a slight extent the SAM model, used some dummy variables to capture the productivity, wage, or price effects of OPEC I. The discussants and participants agreed that the role for such variables should be reduced as far as possible if the models were to be used to predict what might have happened without the OPEC shocks.

I shall turn now to some issues particular to the Bank of Canada paper. As noted by Peter Hooper in his commentary, the SAM model has paid commendable attention to forward-looking expectations. David Rose pointed out that the model's concentration on growth rates rather than expected levels of variables may be partly responsible for what several participants thought to be implausible results; for example, the aggregate domestic price level increasing by more than 60 per cent in response to a doubling of crude oil prices. He emphasized, and I would agree, that the current results are best viewed as indications of the consequences of some initial estimation of substitution possibilities and some selected expectations processes, and not yet used as a guide to the likely effects of alternative energy prices on output, price levels, and stagflation, or the effects of accommodating monetary and exchange rate policies.

The Japanese paper, on the other hand, involved much less in the way of new modelling and much more analysis of the likely impact of oil prices. Three issues stood out:

First, the paper presented the results for Japan both with and without taking account of the effects of energy price shocks on Japan's trading partners. I think this is a very useful form of analysis, which I have already suggested is equally desirable for builders of multinational models. The GNP effects of the shock appear much worse with interdependence, while the domestic inflationary effects are not much different.

Second, the paper concentrated, correctly in my view, on the importance of modelling the wage-price spiral effects of energy price shocks. In this regard, I think that model-builders would be well advised to include the terms of trade either directly or indirectly (as with SAM's use of both the output price and the absorption price in the wage equation) in wage determination.

Finally, the paper examined the effect (also discussed in John Taylor's paper) of inflation on consumer spending. One attractive feature of the Japanese model is the use of an explicit measure of consumer confidence in the consumption equation, while a separate equation is used to explain confidence in terms of the changes in the inflation rate, disposable income, and the unemployment rate. This gives the Japanese model a better empirical basis for estimating the effects of inflation on spending, although there remains the problem of separating the effects of OPEC-induced inflation from the effects of the OPEC I dummies in the confidence equation. However, given the negative signs on these dummies, the downward effects of OPEC inflation on spending are at least not likely to be overstated by the inflation term.

The paper by Bruce White and Rod Deane presented a broad range of simulation results on the effects on New Zealand of import price increases and export price decreases, under a variety of exchange rate assumptions. They found substantial differences between the effects of the two types of foreign price shock. The paper also considers the effects of new classical and other variations in the structure of the model. This was a very helpful addition to the paper. Jung Soo Lee, in his commentary, made helpful comparisons between the Deane and White results for New Zealand and the results reported earlier for Japan, Canada and Korea. Several general questions arose, and I shall try to focus on them.

First, should devaluations have positive or negative effects on real GNP? As long as trade price elasticities are non-zero and if domestic output prices and wages are initially unaffected, then the devaluation will be expansionary, acting through the trade account. Once the inflationary effects from the import price to the absorption price to the wage rate to the output price, and so on around the circle, are taken into account, the expansionary effects can be reversed by the induced reductions in real money balances. Inter-country differences can depend on trade price elasticities, monetary policy reactions, the nature of the price-wage spiral, and so on.

Second, should we expect a rise in import prices to have a downward effect on GNP? Here the result is a more straightforward yes, because of the real income cut implied by the negative change in the terms of trade. It is possible that the net effect on employment, or on the use of some other import-substituting factor should be positive even given the drop in GNP.

Third, should the real wage rise or fall in response to an import price shock? Generally, it should fall, as shown by the New Zealand long-term results, although there is a possibility for the import pass-through into wages to precede the capacity effect and raise the real wage. Factor substitution in favour of labour may also offset the drop in the real wage, especially where there is high substitution between labour and imported materials, but in general, labour, as the recipient of the major share of GNP, is likely to share also in the real income drop.

And finally, should we expect import and export price shocks to have the same impact on the economy? In general no, because importables and exportables are different goods (or else there could not be a change in the terms of trade), and have different price and substitution effects on domestic output, spending, and employment. However, it is still necessary to ensure, as Bruce White pointed out, that the model represents these differences faithfully.

Alan McLean turned us away from econometric modelling altogether, and asked us to consider what sort of monetary and exchange rate strategy was feasible and desirable for Hong Kong. The issue is very important, as the Hong Kong situation appears to be one where the banking and trading community is so internationally oriented that there seems to be no limit to currency substitution and thus no stable asset demand for any class of financial assets denominated in Hong Kong dollars. The Hong Kong dollar price level and foreign exchange rate are therefore indeterminate. The partial government control of bank lending rates could, in principle, squeeze the affected part of the banking system out of Hong Kong dollar-denominated business, either by rates low enough to deter lenders or high enough to deter borrowers. But this would only limit the use of the currency and would not serve to determine its value, so the solution to the puzzle must lie elsewhere.

If the laissez-faire strategy of government is to continue, there are two policy options. One option is just to carry on as is, and let the banking system create Hong Kong dollar assets and liabilities as it chooses, leaving investors to value them as they choose. This leaves open the real possibility that, with fully flexible prices and wages, and no stock demand for Hong Kong dollar assets, there is no anchor for the exchange value of the Hong Kong dollar, thus jeopardizing both the stability of the currency and the long-term profitability of the Hong Kong dollar-denominated banking sector. The second option is to return to a pegged exchange rate, thus tying the stability of the currency to some other currency for which, it is hoped, there is, at least for now, a less shiftable asset demand. A third strategy would be to recognize, if not exactly embrace, the apparently increasing rigidity of nominal HK$ prices and wages (if this should be the case), and let the exchange rate provide the necessary flexibility, becoming the world price of value-added in Hong Kong. The stability of the currency, in this case, depends to some extent on the rigidity of nominal prices, wages, and banking institutions, and thus would tend to encourage policies that would segment Hong Kong dollar markets somewhat from external pressures. Since this option relies on nominal price rigidities, it would seem to be inconsistent with the established laissez-faire preferences of the government, although these preferences may themselves be changing as the population and industrial structure become richer and more stable.

The Hong Kong example provides a vitally interesting test case for the future of fiat monies if some of the trends I noted in my Keynote Address should turn out to be important. This is so because the international nature of Hong Kong is so great that the instability of a stock demand for Hong Kong dollars may be great even while there is still a stable demand for the currencies of many larger and more closed economies.

David Longworth presented an interesting examination of the short-term supply response and the longer term investment reponse of Canadian non-energy resource export industries. The puzzle he addressed was why resource output should have been a smaller proportion of total output in the second half of the 1970s than in the first half, while their output price increased relative to the GDP deflator. The issue is important for any Pacific Basin country with primary resource sectors. Once explicit account is taken of the differing cost structures in resource and non-resource industries, the puzzle does not seem as serious. If, as one would expect, the best resources (whether renewable or non-renewable) are developed first, then as economic growth proceeds there will be sequentially rising costs as the resource industries expand on extensive and intensive margins. If the rest of the economy operates under constant cost conditions, and technical progress is not biased towards one industry group or the other, then we shall expect to find the output of both groups expanding, but the resource output declining as a share of total output while its price increases relative to the output of the rest of the economy. This is, indeed, the broad nature of David Longworth's evidence.

Against this broad background, one would expect to find some short-term variance of resource output in response to foreign demand conditions and prices, and long-term changes in capacity in response to prices that exceed the costs of marginal deposits. This latter response can be offset and qualified by several factors, including:

(i) the scramble for rent shares on existing projects after a commodity price boom, which may scare off new investment;
(ii) the lumpiness and long gestation times for new projects, coupled with their dependence on current cash flow and volatile expectations;
(iii) the possibility, especially for non-renewable resources, that the rise in the current prices may lead to expectations of further increases, and hence to the holding of deposits for future production;
(iv) the possible macroeconomic dislocations of major resource projects; and
(v) the "de-industrializing" effects of a large and temporary increase in resource exports.

The paper was very useful in raising a number of issues that should be important in the future modelling of potential output in a number of Pacific Basin countries.

In his Address to the Conference, George Freeman cautioned that even if there may be circumstances when the policymaker's research and intuition combine to suggest a course of action, the political pressures on the government and its institutions may rule that action out. This suggests that research results, to be effective in the long run, must be persuasive not just to the policy advisers but also to the broader political constituencies to which the policymaker must answer.

A workshop session on papers prepared in the central banks of Malaysia and Mexico concluded the Conference. The Malaysian paper contained some preliminary results from estimates of cost and revenue equations for commercial banks in Malaysia, and led to a useful discussion of the strategy to be followed in such research. My own conclusion was that where data and research resources are scarce it will pay to focus the next stage of the research fairly directly on the policy issues at hand, rather than to replicate studies done using similar data in other countries.

The Mexican paper contained the results of some imaginative specification and reduced-form estimation of a model designed to capture the effects of credit rationing in Mexico. The authors and discussants were fully aware of the difficulties involved in using linear reduced forms to estimate the effects of credit rationing for which the effects are bound to vary non-linearly with the extent to which the controls are binding. It was suggested that the implicit structure of the model might be studied by the presentation of standard multiplier properties in response to changes in conventional instruments, and that attempts be made to introduce some non-linear aspects of the rationing process into the reduced form. Befitting the workshop nature of the session, both papers were more concerned with issues of model structure and estimation than with results and application to policy issues.

To sum up, let me list a few of the many lessons that I have learned from the variety of interesting papers and discussions that we had during the week.

First, the emphasis on the results of applied research has provided a welcome focus, not only in forcing us to draw out the implications of our research but also in making it more useful and comprehensible to researchers in other countries.

Second, the comparison of research results across countries is very informative and ought to be encouraged in the future, even to the extent of suggesting a few common experiments to be run on models of different countries and groups of countries. It is also useful to provide enough institutional data to permit those from other countries to understand the context of the problem under study.

Third, the analysis and modelling of potential output and productivity growth were central to many of our papers and discussions, and provide fruitful areas for model development and a possible theme for a future meeting. Most of the papers concerned with supply shocks pointed out the need for a more extended treatment of their effect on potential output, so such work can been seen as a logical progression.

Finally, on the role for monetary and exchange rate policies in response to supply shocks, the results were too varied to summarize here, but were generally cautious in tone, in keeping with the difficulty of the issues and the incompleteness of the available evidence. Nonetheless, many of us acquired through our discussions a deeper and more useful understanding of the problems in our own and other economies.

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